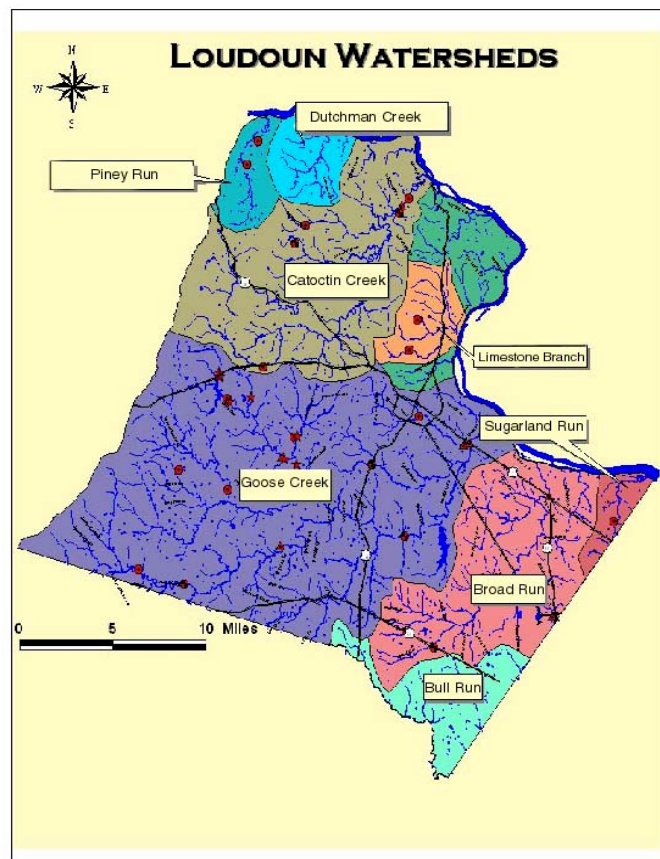


Loudoun County Comprehensive Stream Monitoring Strategy

Plan Design and Guidelines



Loudoun Watershed Watch
September 2003

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

INTRODUCTION

Stream monitoring by state and local government, and citizen watershed organizations plays a critical role in water resource protection and the development of watershed management plans. Monitoring is needed not only to provide baseline data, but also to assess stream health and to resolve degradation problems. Data provided by stream monitoring provides an important component to watershed management plans. These new focuses require a revised strategy and better organization of state and local monitoring efforts.

The Virginia Department of Environmental Quality (DEQ) has determined that most stream in Loudoun have segments that do not meet the Virginia Water Quality Standards and are classified as **impaired**. DEQ is required under the Federal Clean Water Act to establish total maximum daily loads (TMDLs) for pollution sources that cause the impairments. The Virginia Department of Conservation and Recreation (DRC) is required to develop an implementation plan that provides staged reduction targets. A comprehensive, countywide monitoring program that provides statistically valid baseline data can be used to measure the effectiveness of these needed initiatives.

Loudoun County has adopted a Green Infrastructure Strategy to guide the development of environmental policies. This strategy aspires to conserve, preserve, and restore the county's natural resource assets. To help implement the strategy, the Water Resources Technical Advisory Committee has been tasked with the development of a Water Resources Protection Plan. Stream monitoring is a part of the watershed management component of the Water Resources Protection Plan.

CURRENT GAPS IN STREAM MONITORING ACTIVITIES

In 2002 Loudoun Watershed Watch (LWW) published The State of Loudoun Streams: 2002¹ report that provided an assessment of watershed conditions. LWW concluded that Loudoun County needs watershed management plans to implement the Federal Clean Water Act, the Chesapeake Bay Act, the Virginia Water Quality Standards, and the policies of Loudoun's Green Infrastructure and Stream Corridor Overlay District in the Comprehensive Plan. In order to accomplish this Loudoun County should: (1) create a **water management authority** to develop watershed management plans and oversee the implementation of TMDL plans for Loudoun streams; (2) support a **countywide stream monitoring program** to assess changes in stream health and progress in restoring water quality to supplement state efforts; and (3) collaborate to develop an updated **stream monitoring program and strategy** to provide more representative data on watersheds.

In September 2003 the Loudoun County Sanitation Authority (LCSA) issued the findings and draft recommendations regarding the development of a source water protection (SWP)

¹ Loudoun Watershed Watch. "State of Loudoun Streams: 2002." 2002.

program for drinking water in Loudoun County. The gaps in the current stream monitoring activities that are identified in the State of Loudoun Streams: 2002 Report, the SWP Program, and other reports that have been prepared in recent years regarding Loudoun water resources are as follows:

- There is little joint planning or collaboration between state, regional, and county authorities, and citizen groups involved in stream monitoring in Loudoun County. Each entity has unique goals, protocols, sampling stations, and schedules.
- DEQ cannot meet stream monitoring needs on its own and DCR relies largely on county and stakeholder groups to develop TMDL Implementation Plans and watershed management plans. Currently, Loudoun County does not fund stream monitoring activities, and no county authority or other groups are able to respond to decreases in state monitoring to keep monitoring at a minimum acceptable level.
- Most stream monitoring is conducted by DEQ and they only monitor at a limited number of stations. Large sections of watersheds including entire subwatersheds are not sampled.
- Stream monitoring has not been designed to support watershed management planning at the subwatershed level. This has created the overlaps and gaps in data collection, and there is no unbiased stream monitoring data available for Loudoun County collected from randomly selected stations that can be extrapolated to assess stream health over an entire stream length with known statistical confidence.

STREAM MONITORING PROGRAM STRATEGY

The development of watershed management plans that incorporate national, regional, and state legislative commitments as well as community priorities need to be a function of local governments and watershed organizations. It is Loudoun Watershed Watch's vision that Loudoun County government and County Agencies will become the principal authorities that collect water resource data, and prepare and implement watershed management plans with the support of citizen watershed organizations.

In Loudoun County stream monitoring can best be achieved through the collaboration of federal, state, regional, and local authorities; and citizen watershed organizations. A countywide monitoring plan that incorporates the contributions of each party will provide comprehensive coverage and effective use of limited state, county, and volunteer resources.

A well-planned stream sampling design will ensure that resulting data are adequately representative of the target stream and defensible for their intended use. There are two main categories of sampling design: probability-based designs and judgment designs. **Probability-based designs** involve random selection of monitoring sites. This allows statistical inferences to be made about the sampled population from the data obtained. These data allow baseline assessments to be made with an efficient use of resources. **Judgment sampling** involves selection of monitoring sites on the basis of expert knowledge or professional judgment. Such stations can be used to track trends in the water quality in a watershed.

STREAM MONITORING GOALS

On March 6, 2003 state, regional, and local stakeholders participated in the “Comprehensive County Stream Monitoring Plan Design Development Conference” sponsored by Loudoun Watershed Watch. The purpose of the conference was to identify the stream monitoring goals needed for a comprehensive stream monitoring program for Loudoun County. Participants agreed that healthy streams have a diversity of aquatic life, stable stream banks and substrates, vibrant native vegetation, and healthy floodplain and buffer areas. Stream monitoring should be directed at helping to achieve the goals needed to realize this vision.

- **Goal #1: Characterize and Assess Stream Health:**
 - To develop baseline data using probability sampling to characterize the health of a stream To determine whether water quality standards are being met
 - To provide data to develop watershed management plans To establish stream preservation and restoration priorities
- **Goal #2: Provide Trend Assessments and Forecasts:**
 - To document water quality trends over time
- **Goal #3: Evaluate TMDL Implementation and Watershed Management Plans:**
 - To determine whether TMDL implementation is working
 - To determine if watershed management plans are effective
- **Goal #4: Provide Environmental Stewardship and Education:**
 - To educate the community regarding pollution prevention and environmental stewardship
 - To demonstrate citizen concern regarding water quality and stream health
- **Goal #5: Coordinate State, County, and Citizen Resources:**
 - Divide monitoring needs rationally between state, county, and citizen groups

STREAM MONITORING DESIGN

In May 2003 Loudoun Watershed Watch sponsored the “Loudoun County Stream Monitoring Strategy Workshop.” At this two-day workshop, state, regional, and local stakeholders outlined a structure for an updated stream monitoring program. The following sampling designs were agreed upon to achieve the different monitoring goals.

Probabilistic Monitoring Design – The probabilistic monitoring design is used to characterize the impact of nonpoint pollutants and other stress factors on the health of benthic communities and stream habitats in wadeable streams. It provides comprehensive information about large geographic areas, while keeping costs reasonable. Loudoun County should follow the sample design recommended by DEQ and collect samples once at each probabilistic site. Sampling should occur during mid-March to mid-May to compensate for seasonal variations and different phases of benthic organism life cycles. Sites should be proportionally distributed among major subwatersheds on the basis of size in acres. Site selection should also be stratified by stream order to assure approximately equal representation among 1st, 2nd, 3rd and 4th order streams.

Watershed Survey Design – A watershed survey is the collection of new and existing information on conditions and processes at the watershed level.² This information can be used to identify the type of additional monitoring that may be needed and problem areas for corrective action, and to bolster watershed awareness and education at all levels, including the individual landowner, community groups, and county authorities.

A watershed survey is an important step in developing watershed management plans. It has two parts:

- **Information Research Survey** – Existing information from reports, interviews, and public meetings regarding stream and watershed conditions and characteristics is compiled; and
- **Field Surveys** – Field data and visual observations on various watershed conditions and characteristics are collected.

Trend Monitoring Design – Representative water quality data from any permanent monitoring station can be used to evaluate trends in water quality at the station. Documentation of short-term, mid-term, and long-term trends can be used to assess water quality and best management practices implemented to restore water quality. Trend sampling stations must be carefully selected based upon professional judgment to provide data to answer specific questions about water quality and stream health.

Trend data from one monitoring site can be combined with other trend data to produce trend analyses for larger drainage areas. The sampling methods and laboratory analytical methods must be standardized to combine data from various stations or to compare trends in different streams. Further, the timing of sample collection must be kept relatively constant from month to month and year to year in order not to introduce additional variables.

TMDL Validation Monitoring Design – A validation assessment is designed to document the effectiveness of the best management practices (BMPs) that have been installed to improve the water quality. The primary assessment conducted by DEQ will be limited to small stream segments currently designated as impaired. Supplemental assessments conducted by Loudoun County and citizen groups will target stream segments not monitored by DEQ. If data results suggest that the implemented management controls are not effective, recommendations on redesigning the management controls are considered by DEQ. Data collected through the Probabilistic and Trend monitoring designs will be used to validate TMDL implementation.

RECOMMENDATIONS

Loudoun Watershed Watch's recommends³ that Loudoun County government and County Agencies become the principal authorities that collect water resource data, and prepare and

² Pennsylvania Citizen's Volunteer Monitoring Program and River Network. "Designing Your Monitoring Program." 2001. p. 5-6.

³ Loudoun Watershed Watch. "State of Loudoun Streams: 2002." 2002.

implement watershed management plans with the support of citizen watershed organizations. Stream monitoring can best be achieved through the collaboration of federal, state, regional, and local authorities; and citizen watershed organizations. A countywide stream monitoring plan that incorporates the contributions of each party will provide comprehensive coverage and effective use of limited state, county, and volunteer resources. The following are needed to adopt a countywide stream monitoring program.

State agencies have the legal mandate and professional staff to monitor streams and ensure that state water quality standards are met. DEQ and DCR should provide:

- Technical guidance;
- Training and QA oversight;
- Laboratory support for benthic macroinvertebrate identification; and
- Utilization of county and citizen data in the validation of TMDL implementation.

County Government and Agencies – Loudoun County and County Agencies have laws and ordinances that protect stream corridors. They have professional staff to provide safe drinking water, monitor and control point discharges of pollution, protect citizens from water related health hazards, and monitor and manage stormwater facilities, as resources permit. The County and County Agencies also have contract funds to conduct drinking water source protection studies, to monitor surface and groundwater resources, and to begin developing watershed management plans. Loudoun County and County Agencies should:

- Fund full-time and part-time positions to administer a stream monitoring program, collect monitoring samples, and ID macroinvertebrate samples;
- Provide funding support for citizen stream monitoring data collection;
- Provide training and QA oversight of county operations; and
- Provide chemical test kits, mapping, GPS units, data analysis, and website support for a countywide stream monitoring program.

Citizen Groups – Citizen groups and environmental organizations help lead efforts in Loudoun County to promote environmental stewardship and stream habitat protection. These groups provide trained volunteers who collect water samples for physical and chemical analyses, monitor benthic macroinvertebrates, and assess stream habitats. Environmental organizations have trained staff to provide environmental education. Citizen groups should provide:

- Citizen Stream Monitoring and Watershed Survey Coordinators;
- A Stream Monitoring Protocol Committee;
- Citizen stream monitor and watershed survey volunteers;
- Training for stream monitors; and
- Field QA implementation.

INTRODUCTION

Loudoun Watersheds

Loudoun County is rich in natural resources including a large network of streams in three major and several smaller watersheds. These watersheds are shown in **Figure ____**. The watersheds in Loudoun are part of the larger Potomac River watershed.

In the past ten years, Loudoun County has experienced tremendous residential and commercial growth, and a population that has almost doubled. Forest and farmlands have been converted to suburban and industrial parks throughout the county, especially in eastern and middle sections. The shift from natural ground cover that allows rainwater to infiltrate into the ground to extensive impervious surfaces that prevent infiltration greatly increases rainfall runoff and peak stream flow volumes. Resulting high flows erode stream banks and cause downstream flooding. In addition, rainwater runoff from urban/suburban developments, industrial parks, and roadways picks up oil, grease, heavy metals, trash, sediment, pesticides, fertilizers, and fecal contamination. These pollutants enter the waterways and threaten the quality of streams and the environment as a whole.

Benefits of Stream Monitoring to Loudoun County

Stream monitoring by state and local government, and citizen watershed organizations plays a critical role in water resource protection and the development of watershed management plans. The Department of Environmental Quality (DEQ) reports⁴ that intergovernmental agreements such as the Chesapeake Bay Preservation Act are demanding more of state and local monitoring programs. Monitoring is needed not only to provide baseline data, but also to assess stream health and to resolve degradation problems. Data provided by stream monitoring provides an important component to watershed management plans. These new focuses require a revised strategy and better organization of state and local monitoring efforts.

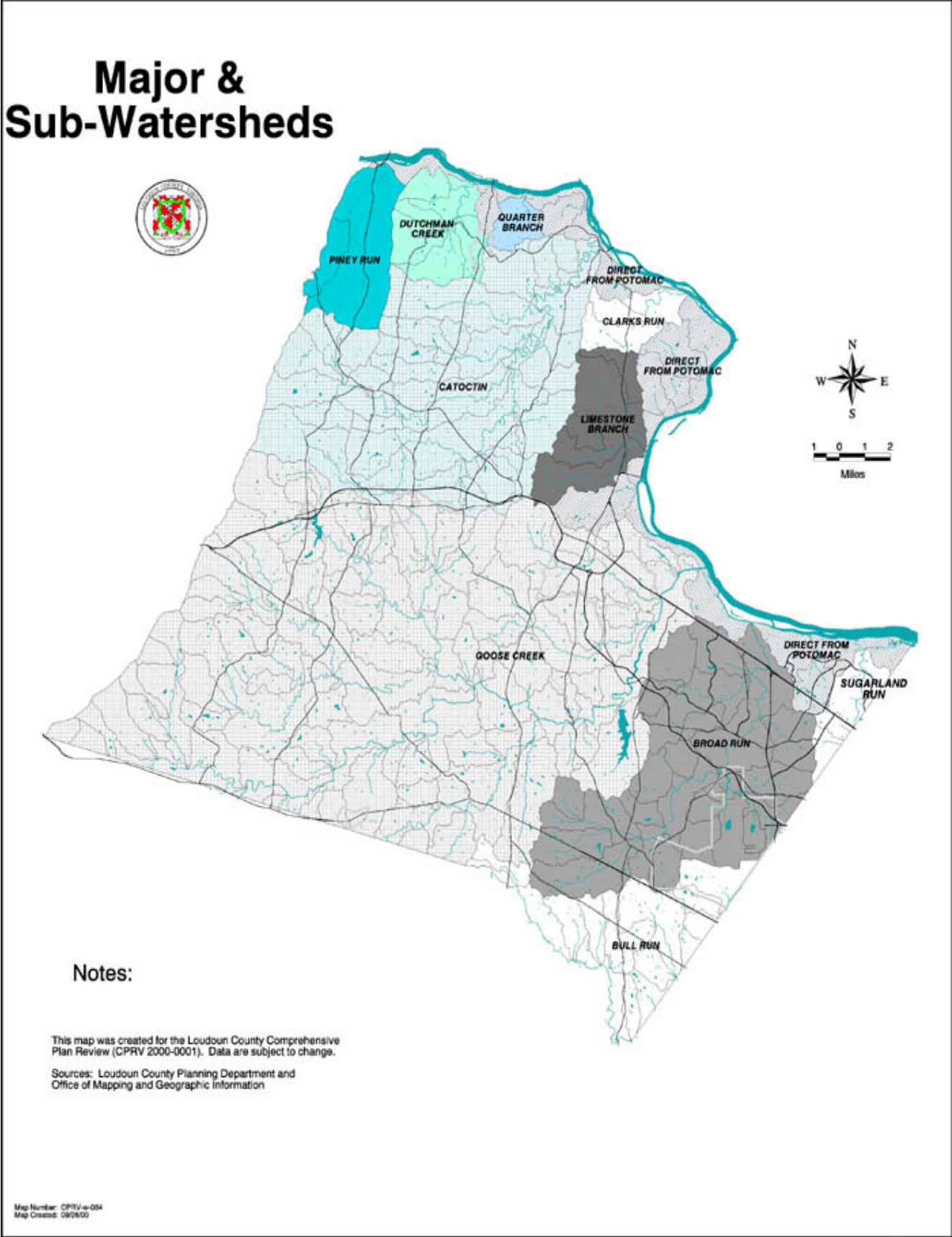
The assessment, protection, and restoration of local watersheds provide a variety of benefits for Loudoun County's environmental resources. Stream monitoring and the watershed management plans it supports can protect and improve the quality and quantity of water for the survival of fish, wildlife, and people. Stable floodplains and buffer systems, with a diversity of native flora and fauna, reduce the likelihood of flood events and provide aesthetic benefits like natural beauty and community-wide recreation opportunities.

Effective watershed management can help communities ensure that surface and ground water supplies do not become degraded over time, that drinking water supplies are sustained, that soil and streambank erosion is reduced, and that wildlife habitat is restored. Watershed management plans can also enhance real estate values for homes and businesses located near

⁴ Virginia Department of Environmental Quality (DEQ). 1999. "Virginia's Water Quality Monitoring Strategy." Draft: December 1999.

river greenway trails, protect parks and open spaces, and restore recreational opportunities for fishing and canoeing.

Figure __. Major and Subwatersheds in Loudoun County, VA.



Regulatory Basis for Stream Monitoring⁵

The development of a comprehensive stream monitoring program will lead to improved management of county watersheds. Stream monitoring and the development of watershed management plans will enable Loudoun County to meet new regulatory requirements, including the Total Maximum Daily Load (TMDL) and storm water provisions of the federal Clean Water Act. It will also help Virginia meet its commitments under the Chesapeake 2000 Agreement that stipulates that, by 2010:

- Virginia will work with local governments, community groups, and watershed organizations to develop and implement locally supported watershed management plans in two-thirds of the Bay's watersheds; and
- Local watershed management plans will address the protection, conservation, and restoration of stream corridors, riparian buffers, and wetlands for the purpose of improving habitat and water quality.

Designated Use Standards for Streams

Loudoun County streams are designated for two uses⁶:

- recreational uses (e.g., swimming and boating); and
- the propagation and growth of a balanced indigenous population of aquatic life, including game fish which might reasonably be expected to inhabit them; wildlife.

These designated uses determine the water quality criteria applicable to Loudoun streams. There are chemical and bacteriological criteria for temperature, pH, dissolved oxygen, ammonia, chloride, and fecal coliform bacteria. These standards are listed in **Table __**. There are no standards for other parameters such as nitrogen, phosphorous, turbidity, suspended solids, or biological oxygen demand (BOD).

Table __. DEQ Water Quality Standards for Recreational Use in Piedmont Zones⁷.

Parameter	State Standard (Acute/Chronic)	Significance
Temperature	Maximum = 32 ⁰ C	Affects rates of chemical processes in cells and the water's dissolved oxygen content
pH	6.0 – 9.0	Level of acidity -- affects cell membrane functions
Dissolved Oxygen (DO)	Minimum = 4 mg/l & Daily Avg. = 5 mg/l	Affects biological metabolism

⁵ Firehock, Karen. "A Watershed Planning Primer for Virginia," University of Virginia, 2003.

⁶ Virginia State Water Control Board. 1997. *Water Quality Standards*.

⁷ Virginia State Water Control Board. 1997. *Water Quality Standards*.9 VAC 25-260-5 et seq.

Parameter	State Standard (Acute/Chronic)	Significance
Ammonia	0.86 – 32 mg/l as N acute/ 0.19 – 3.02 chronic ¹	Form of nitrogen that in excess causes eutrophication and loss of dissolved oxygen; a toxin
Chloride	860/ 230 mg/l	Indication of salt content
Fecal Coliform Bacteria	200 colonies/100ml or no more than 10% \geq 400/100ml per month ⁸	Common bacteria in animals' digestive tracts. Indicator of human sewage or animal droppings

¹ Standard varies with temperature and pH

DEQ's Classification of Loudoun Streams

DEQ stream monitoring data identify stream segments that do not meet the Virginia Water Quality Standards and are classified as **impaired**. In Loudoun County existing data has already established that most streams have impairments. Virginia is required under Section 303(d) of the Federal Clean Water Act to issue a biennial 303(d) list of impaired waters. The impaired streams in Loudoun County are listed in **Table __** and shown in **Figure __**.

Table __. Impaired Waters in Loudoun Water.

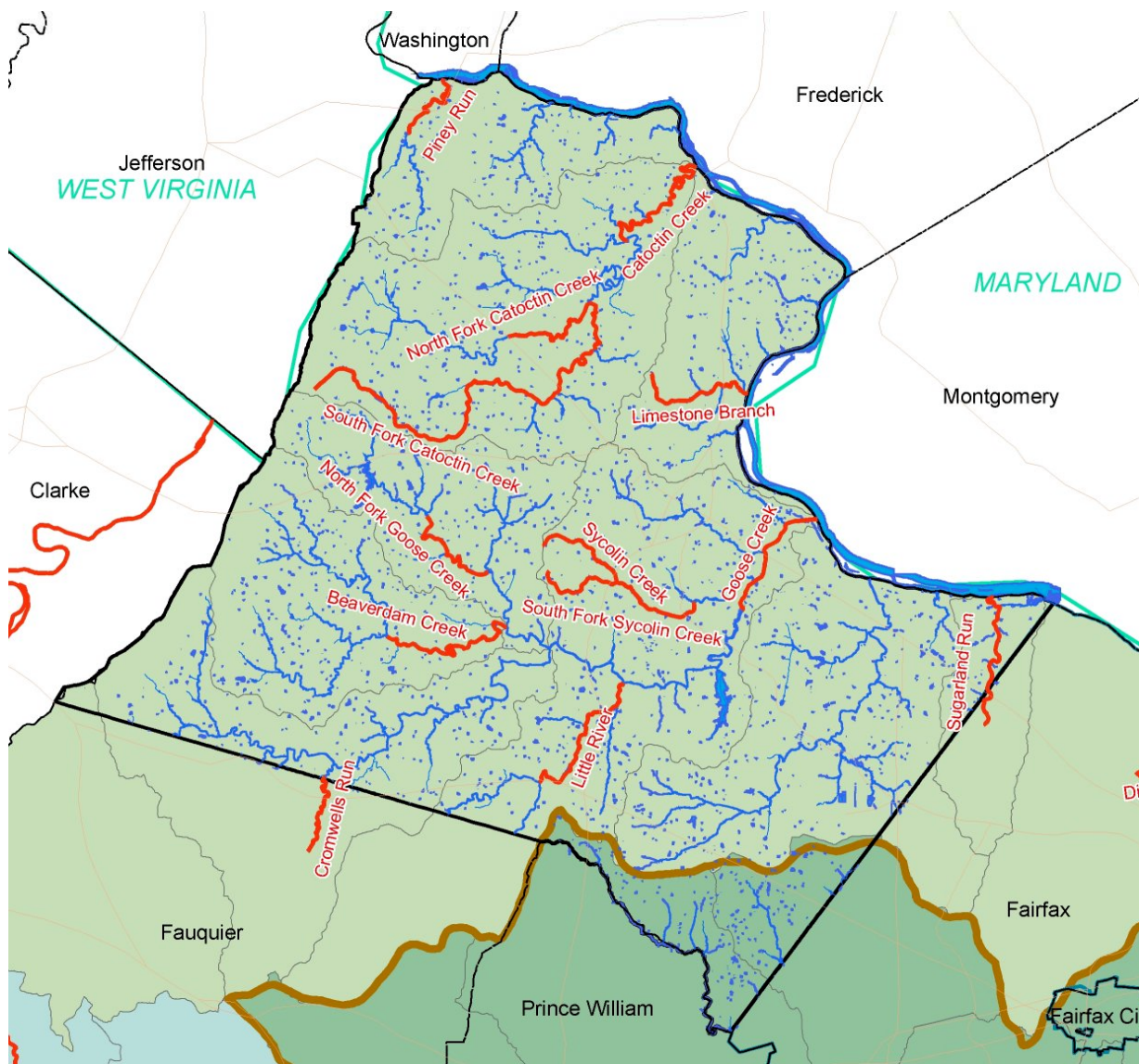
<i>Stream Name</i>	Cause	Data Source	Fecal Coliform	First Listing
Piney Run	FC	DEQ	P	1998
Catoctin Creek	FC	DEQ	P	1994
NF Catoctin Creek	FC	DEQ	N	1994
SF Catoctin	FC, Benthic	DEQ, Citizen	N	1994
Limestone Branch	FC	DEQ	N	2002
Goose Creek	FC	DEQ	P	1998
Cromwells Run	FC	DEQ	N	1998
NF Goose Creek	FC, Phosphorus	DEQ	N	1998
Beaverdam Creek	FC	DEQ	N	1998
Little River	FC	DEQ	N	1998
Sycolin Creek	FC	DEQ	N	1996
SF Sycolin Creek	FC	DEQ	N	2002
Sugarland Run	FC, Benthic	DEQ, Citizen	P	2002

P=Partially supporting; N= Non-supporting

⁸ DEQ. 2002. Public Hearing, Water Quality Standards–Triennial Review. Amendment adopted May 2002 that will “sunset” after 12 data points or June 2008 when an *E. coli* standard will be adopted.

Total Maximum Daily Loads (TMDLs)

DEQ is required under the Federal Clean Water Act to establish total maximum daily loads (TMDLs) for pollution sources that cause the impairments. The TMDLs are developed to delineate pollution load allocations and a margin of safety to provide reasonable assurance that

Figure __. DEQ Designated Impaired Waters in Loudoun County – 2003.

those streams will be restored to their designated uses. The TMDLs are based upon a model that predicts the response of the stream to different levels of pollution loads. These predictions are used to establish pollution load allocations that must be met if the stream is to meet the water quality standards.

The Virginia Department of Conservation and Recreation (DRC) is required to develop an implementation plan that provides staged reduction targets. The implementation plan relies upon voluntary application, and is to be administered by local officials. DEQ is to track the effectiveness of pollution controls and implementation. Restoring the health of streams will

require protecting existing forested riparian buffer zones and installing best management practices along degraded stream corridors. Better control and natural treatment of stormwater runoff is also needed. A comprehensive, countywide monitoring program that provides statistically valid baseline data can be used to measure the effectiveness of these needed initiatives.

Loudoun County Water Resource Protection Plan

Loudoun County has adopted a Green Infrastructure Strategy to guide the development of environmental policies. This strategy aspires to conserve, preserve, and restore the county's natural resource assets. To help implement the strategy, the Water Resources Technical Advisory Committee has been tasked with the development of a Water Resources Protection Plan. The plan is to have three components: (1) water quality protection, (2) water quantity protection, and (3) watershed management. Stream monitoring is a part of the watershed management component of the Water Resources Protection Plan.

CURRENT STREAM MONITORING ACTIVITIES IN LOUDOUN COUNTY

The federal Clean Water Act of 1972 guarantees citizens the right to be informed about the quality of their drinking and recreational waters, and to help keep these waters healthy. Water quality standards establish numerical criteria for the safe use of waters for aquatic life, drinking, swimming, fishing, and boating. The intent is to limit pollutants entering a stream so degradation that prevents these uses does not occur. To meet these requirements and to keep citizens informed, stream monitoring is being conducted in Loudoun County at many locations by federal, state, and local authorities, and by watershed organizations and citizen groups.

There are several parameters being used to measure human impacts that upset the balanced conditions found in a natural stream ecosystem and cause major degradation problems to the stream water. These parameters include measurements of: (1) physical and chemical quality, (2) water flow, (3) bacteriological quality, (4) stream habitat, and (5) the type of organisms living in the stream. Water quality programs have traditionally relied on chemical and bacterial indicators to assess quality because government programs have historically focused on controlling point discharges of pollutants such as sewage treatment plants. Most data collected by DEQ in Loudoun County is physical, chemical, and bacteriological data. Evaluating water quality by using key physical, chemical, and bacteriological indicators can reveal degradation from nonpoint pollution sources as well.

Biosurvey parameters are used to monitor pollutants that affect aquatic organisms, and to evaluate the relative seriousness of the impacts. Aquatic organisms (also called benthic macroinvertebrates) include the aquatic insects, crayfish and other crustaceans, clams and mussels, snails, aquatic worms, and other similar organisms. These organisms are excellent indicators for assessing streams because they cannot escape changes in water quality. Each insect has requirements that the stream must provide for the insect to flourish. By determining the number and type of insects that live in a stream, the quality of the water and the health of the stream environment can be assessed.

A list of stream monitoring stations and the type of monitoring data available for each station is provided in **ATTACHMENT __**. A map showing these stations is provided in **Figure __** (*to be added*).

Federal and Regional Government –

- US Geological Survey (USGS)– USGS collects chemical, sediment, and stream flow data at stations in Goose and Catoclin Creeks. Eight additional stations in other streams were added in 2002.
- Metropolitan Washington Council of Governments (COG) – COG has conducted baseline biological monitoring surveys in several Loudoun County streams under contract with the county. The surveys focus on non-point pollution problems using assessments of stream habitat and benthic macroinvertebrates, and include prioritized recommendations regarding preservation and restoration needs. They have completed studies of Sugarland Run, Talbot Farm Tributary, and Catoclin Creek. They are

currently completing studies of the Goose Creek, Catoctin Creek, Broad Run, Limestone Branch, Dutchman Creek and Piney Run mainstem conditions.

DEQ – The Virginia Department of Environmental Quality (DEQ) collects stream monitoring data to identify watersheds that are impaired (i.e., streams that do not meet state water quality standards and the federal Clean Water Act). These streams are listed in DEQ's biennial 305(b) report to the public, the U.S. Environmental Protection Agency (EPA), and the Congress. DEQ collects stream quality data at 16 to 18 stations in Loudoun as part of Virginia's ambient water quality monitoring network. DEQ also collects stream habitat and macroinvertebrate data at 3 stations. The number of sampling stations and sampling frequency was reduced in 2001.

DEQ's sampling strategy for Loudoun County provides monitoring that is rotated between different subwatersheds every two years in a six-year cycle. Twelve samples are taken at each site over the 6-year period. In addition, a number of trend stations located near stream flow gauges are sampled routinely. DEQ is also sampling streams on a random basis statewide, but so far no stations in Loudoun County have been selected. The number of stations is selected on the basis of watershed size, stream order, and nonpoint pollution potential rating done by the Department of Conservation and Recreation.

- **Physical, Chemical, and Bacteriological Monitoring** – Most DEQ sampling assesses physical, chemical, and bacteriological parameters to determine whether the stream water meets state water quality standards.
- **Biosurvey Monitoring** – DEQ does some aquatic insect and stream habitat monitoring to determine whether streams meet aquatic life criteria – currently at three stations in Catoctin Creek, Little River, and Goose Creek.
- **Reference Stream Sampling** – DEQ is also doing biosurvey monitoring to identify better reference streams to use to assess the health of the streams they are monitoring.
- **Changes in DEQ Monitoring** – In recent years DEQ has changed its stream monitoring program to spread its monitoring efforts over more of the state's waters, and to better respond to water quality problems found during monitoring efforts. The new plan has substantially change DEQ's water quality monitoring activities in Loudoun County. These changes are summarized on **Table __**. This table shows that the number of monitoring stations has been reduced from 23 to 12, and the number of samples reduced from 174 in 1999 to 72 in 2001.

Table __. Summary of Changes Under the New DEQ Water Quality Monitoring Plan for Loudoun County.

Old Monitoring Plan	New Monitoring Plan
• Number monitoring stations = 22	• Number monitoring stations = 15
• Frequency of monitoring = monthly	• Frequency of monitoring = bimonthly
• Number samples collected: <ul style="list-style-type: none"> ○ 1999 = 174 ○ 2000 = 123 	• Planned # samples to be collected: <ul style="list-style-type: none"> ○ 2001 = 72 ○ 2002 = 81*
• # Stations monitored routinely = 23	• # Stations monitored routinely = 10

• # Macroinvertebrate stations = 3	• #Macroinvertebrate Stations =?
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* Sampling through 3/02

Loudoun County and County Agencies — There are several county authorities and agencies that monitor Loudoun streams. Monitoring includes assessing physical, chemical, and bacteriological water quality parameters.

- Loudoun County Sanitation Authority (LCSA) – LCSA monitors point wastewater and drinking water treatment discharges throughout the county. It does not routinely monitor streams, but does special studies at sites of proposed discharges. One such special study is being done on Broad Run. LCSA also conducts drinking water source protection studies that include limited assessments of riparian buffers and stream erosion. A study was completed in 2003 on the Beaverdam Reservoir in the Goose Creek watershed.
- Loudoun County Soil and Water Conservation District (LCSWCD) – LCSWCD monitors selected streams, assists volunteer citizen groups, and works with landowners to install agricultural best management practices.
- Loudoun County Building and Development (LCB&D) – LCB&D is seeking \$1.6 million over five years in grant funds for water resource monitoring.

Citizen and Environmental Groups – Loudoun County citizens have formed local watershed committees or have joined countywide and regional groups with water monitoring programs. These groups monitor basic physical and chemical parameters, and benthic macroinvertebrates. Volunteer citizen groups active in Loudoun include:

- Loudoun Wildlife Conservancy
- North Fork Goose Creek Watershed Committee
- Wancopin Creek Watershed Neighbors

Monitoring data collected by citizen groups have historically been compiled by LSWCD and entered into a database. These data have been shared with county authorities, town managers, and others interested in streams. Citizen data also have been sent to DEQ. In 2000 Loudoun Wildlife Conservancy began compiling data on a countywide basis. These data were used to prepare a report titled, “State of Loudoun Streams: 2002,” by Loudoun Watershed Watch.

Piedmont Environmental Council (PEC) and Goose Creek Association (GCA) – PEC and GCA contracted with the Center for Watershed Protection (CWP) in 2001 to conduct a “Rapid Watershed Assessment of the Goose Creek Watershed.” This assessment included baseline stream habitat data in three subwatersheds, and recommendations regarding preservation and restoration needs.

CURRENT GAPS IN STREAM MONITORING ACTIVITIES

State of Loudoun Streams

In 2002 Loudoun Watershed Watch published The State of Loudoun Streams: 2002 report that provided an assessment of watershed conditions based on analyses of stream habitat, aquatic insect communities, and physical and chemical data collected by government and citizen groups at trend stations. This was the first time that monitoring data from state, regional, local, and volunteer groups was integrated into a comprehensive report on Loudoun streams. The findings of the report were:

- **Nonpoint sources of pollution (NPS)** affect all Loudoun streams. The state rates the impact as high for 67% of the streams. The main sources include urban storm water runoff, agricultural and grazing activities, failing septic tank systems, and wildlife. Failure to maintain riparian buffers and install adequate storm water, agricultural, and grazing best management practices (BMPs) are the principal reasons bacteriological quality and aquatic life in streams are degraded.
- **Increases in the amount of impervious surfaces** in watersheds that aggravate the effect of storm water runoff affect stream health. Assessments show that 22% of Loudoun streams are highly to moderately impacted. It is doubtful that streams highly impacted can be restored to health conditions. The high rate of development is causing more streams to be affected.
- The **bacteriological quality** of Loudoun stream water is generally marginal to poor. The poor quality is attributed to fecal contamination from nonpoint pollution sources. These high levels of contamination have existed for several years, although a couple of streams have shown improvement. Half of Loudoun streams exceed the fecal coliform water quality standard 30% or more of the time.
- The health of **stream habitats** varies considerably between streams. Monitoring sites on approximately 25% of the streams show marginal habitat conditions due to poor riparian buffers in agriculture areas, unstable banks due to high runoff episodes, and filling-in of stream bottoms with eroded sediments. These conditions have remained fairly consistent over the last several years.
- Conditions for **aquatic life** remain good at monitoring sites in almost 70% of the streams. There is good diversity of aquatic insects, and pollution intolerant species, such as mayflies, predominate. Monitoring sites in 30% of the streams show poor diversity and many more pollution tolerant species of insect such as midge larva. Biological conditions fluctuate considerably from year to year.

Recommendations – The report concluded that Loudoun County needs watershed management plans to implement the Federal Clean Water Act, the Chesapeake Bay Act, the Virginia Water Quality Standards, and the policies of Loudoun's Green Infrastructure

and Stream Corridor Overlay District in the Comprehensive Plan. In order to accomplish this, the following were recommended.

- Loudoun County should create a **water management authority** to develop watershed management plans and oversee the implementation of TMDL plans for Loudoun streams. A system of small subwatersheds should be identified that provide homogeneous management areas. Additional information regarding impervious cover and loss of forest lots will aid management planning. The authority needs to work with the Loudoun Watershed Watch to bring together stakeholders to support this process.
- Agricultural sources of nonpoint pollution are degrading Loudoun streams. Loudoun needs additional cost sharing and tax-incentive programs to encourage landowners to install **agriculture best management practices** to protect streams including fencing to protect streams from livestock.
- Loudoun County needs to support a **countywide stream monitoring program** to assess changes in stream health and progress in restoring water quality to supplement state efforts. The program should utilize low cost methods to assess bacteriologic quality, habitat conditions, and biological conditions.
- An updated **stream monitoring program and strategy** is needed for Loudoun County if the county is to play a leadership role in water resource protection. The updated strategy should focus on providing more representative data on watersheds, and on measuring the effectiveness of stewardship initiatives to restore water quality. This can be best accomplished by randomly selecting additional monitoring sites in each watershed to provide a **probabilistic sampling program**. A better balance between assessments of chemical, bacteriological, habitat, and biological parameters is needed to provide an accurate picture of stream health conditions. Increased monitoring by county and citizen groups should be encouraged to offset reductions in monitoring by the state.

Goose Creek Source Water Protection

In September 2003 the Loudoun County Sanitation Authority (LCSA) issued the findings and draft recommendations regarding the development of a source water protection (SWP) program for Loudoun County. This program is needed to protect drinking water sources within the Goose Creek watershed. The plan adopts a multi-barrier approach that will protect against: (1) detrimental increases in nutrients and sediments; (2) impacts of urbanization and agriculture; and (3) public health risks. Protections will include: (1) pre- and post-development best management practices (BMPs) regarding enhanced erosion and sediment controls; (2) riparian buffers and corridors within the watershed including riparian buffer restoration; and (3) enhanced floodplains and wetlands.

The SWP program includes a “risk monitoring & compliance” component that relies upon stream monitoring. Enhanced stream monitoring is needed to assess: (1) water quality and quantity; (2) stream habitats; (3) aquatic life (benthic macroinvertebrate) populations; and (4)

stream cross-sections to assess erosion levels. To accomplish this needed stream monitoring, the report recommends:

- The development of partnerships to consolidate stream monitoring efforts;
- The provision of reliable funding for monitoring activities;
- Tracking implementation progress and prioritizing activities; and
- Public involvement and outreach.

Stream Monitoring Gaps

The gaps in the current stream monitoring activities that are identified in the State of Loudoun Streams: 2002 Report, the SWP Program, and other reports⁹ that have been prepared in recent years regarding Loudoun water resources are outlined in the following.

- **Integrated Monitoring Plans and Guidelines** – There is little joint planning or collaboration between state, regional, and county authorities, and citizen groups involved in stream monitoring in Loudoun County. Each entity has unique goals, protocols, sampling stations, and schedules.
- **Local Monitoring Relies on and is Constrained by State Resources** – Virginia currently ranks 50th among states in percentage of the state budget dedicated to funding natural resource programs (0.6 %). DEQ cannot meet stream monitoring needs on its own. Instead, DEQ relies on regional, county and citizen groups to collect data to help identify water quality problems. DCR relies largely on county and stakeholder groups to develop TMDL Implementation Plans and watershed management plans. Currently, Loudoun County does not fund stream monitoring activities.
- **Minimum Acceptable Level of Monitoring Not Maintained** – Changes and cutbacks in monitoring by one group are not being offset by increased efforts by other groups. For example, in 2001 DEQ substantially changed their water quality monitoring activities in Loudoun County. The number of trend monitoring stations sampled in any one year changed from 23 to 12, and the number of samples collected was reduced from 174 in 1999 to 72 in 2001. No county authority or other groups were able to respond to this change to keep monitoring at a minimum acceptable level.
- **Overlaps and Gaps in Monitoring Coverage** – Most stream monitoring is conducted by DEQ, and they can only sample a limited number of stations. Large sections of watersheds including entire subwatersheds are not sampled. For example, there is only one DEQ sampling station in the Broad Run watershed that is Loudoun County's third largest. The opposite may be true in other watersheds. For example, the North Fork Goose Creek watershed is one of the most monitored of all Loudoun watersheds. DEQ, LSWCD, LWC, and NFGC all have monitoring stations, sometimes at the same location.

⁹ Reports have been prepared by the Loudoun Environmental Indicators Project; the Center for Watershed Protection incorporation with the Piedmont Environmental Council and the Goose Creek Association; and the Council of Governments.

- **Different Protocols Utilized** – Monitoring authorities and citizen groups use different protocols that often make data incompatible. DEQ has a unique protocol based upon EPA's Rapid Bioassessment Protocol (RBP). LWC's protocol is also based upon EPA's RBP but with some modifications to accommodate citizen monitors. LCSWCD and North Fork Goose Creek Association use the Save Our Streams (SOS) protocol developed by the Izaak Walton League. Council of Governments (COG) uses a Rapid Stream Assessment Technique (RSAT) that they developed. The Center for Watershed Protection (CWP) uses a Riparian Improvement Tracking (RIT) protocol they developed. Loudoun County authorities contract out stream assessments to environmental engineering firms that use their own protocols.
- **Countywide Coverage** – In the past stream monitoring has not been designed to support watershed management planning at the subwatershed level. Instead, monitoring stations have been selected to assess compliance with state water quality standards, or to assess a particular stream or stream segment of interest to a local citizens group. This has created the overlaps and gaps in data discussed above.
- **Random Data from Probabilistic Stations** – There is no unbiased stream monitoring data available for Loudoun County collected from randomly selected stations that can be extrapolated to assess stream health over an entire stream length with known statistical confidence. Stream monitoring data, collected to date, have been used to track trends in water quality at specific targeted locations. Sampling stations have been selected based upon professional judgment in the case of DEQ, and lay judgment for citizen monitoring stations. Sites are normally located near a bridge and have public access. Data collected at these targeted stations are biased, not random, and results are only applicable to the particular site being sampled.¹⁰ Assessment results cannot be extrapolated to assess overall water quality and stream health conditions in a subwatershed. These assessments are needed to establish watershed protection strategies and stream restoration priorities.

¹⁰ U.S. Fish & Wildlife Service. "Freshwater Biomonitoring Using Benthic Macroinvertebrates." National Conservation Training Center. May, 2003

STREAM MONITORING PROGRAM STRATEGY

Program Visions

Watershed management planning requires prioritizing goals, and addressing needs that incorporate a wide range of social, economic, and environmental factors.¹¹ Considerations about water quality, stream management, habitat restoration, and the relationship between land use planning and healthy watersheds are key components of watershed plans. The development of watershed management plans that incorporate national, regional, and state legislative commitments as well as community priorities needs to be a function of local governments and watershed organizations.

- **Virginia** – It is the vision of Virginia State government agencies¹² that local government and watershed groups will become the principal authorities that prepare watershed management plans. Under the Chesapeake 2000 Agreement, Virginia agreed to “work with local governments, community groups, and watershed organizations to develop and implement locally supported watershed management plans.” These plans are to address the protection, conservation, and restoration of stream corridors, riparian buffers, and wetlands for the purpose of improving habitat and water quality. The development of effective watershed management plans will enable Virginia to meet the Total Maximum Daily Load (TMDL) and storm water provisions of the federal Clean Water Act.
- **Loudoun County** – It is Loudoun Watershed Watch’s (LWW) vision¹³ that Loudoun County government and County Agencies will become the principal authorities that collect water resource data, and prepare and implement watershed management plans with the support of citizen watershed organizations. In the short term, Loudoun government and agencies lack adequate resources to accomplish these tasks. As a result, the proposed stream monitoring program strategy relies heavily upon citizen volunteers as a key component to begin data collection. As county government and agency water quality protection and restoration programs grow, the citizen’s role in data collection should decrease proportionately. The long-term citizen role is envisioned to focus on watershed plan implementation, environmental stewardship, and community education.

Program Collaboration

In Loudoun County stream monitoring can best be achieved through the collaboration of federal, state, regional, and local authorities; and citizen watershed organizations. A countywide monitoring plan that incorporates the contributions of each party will provide comprehensive coverage and effective use of limited state, county, and volunteer resources. The contributions of each party to a joint strategy are as follows.

¹¹ Firehock, Karen. “A Watershed Planning Primer for Virginia,” University of Virginia, 2003.

¹² Firehock, Karen. “A Watershed Planning Primer for Virginia,” University of Virginia, 2003.

¹³ Loudoun Watershed Watch. “State of Loudoun Streams: 2002.” 2002.

- **EPA** – The Federal Environmental Protection Agency (EPA) administers the Federal Clean Water Act and oversees implementation of the Act by the Virginia Department of Environmental Quality (DEQ). EPA sets standards and provides guidelines for water quality monitoring, stream protection, and water quality restoration. Loudoun County receives grant funds and technical guidance from EPA.
- **USGS** – The US Geological Survey (USGS) records stream flows at ten locations in Loudoun County, and provides real-time flow data. USGS also provides grant funds and technical guidance on water quality, and stream protection and restoration.
- **DEQ and DCR** – State agencies have the legal mandate and professional staff to monitor streams and ensure that state water quality standards are met. They have a large amount of trend monitoring data at stations throughout the county. They provide grant funds and technical support to local governments and citizen groups as resources permit regarding monitoring, watershed management planning, and pollution control. DEQ uses county and citizen data to help identify threatened waters that need state study.
- **County Government and Agencies** – Loudoun County ordinances provide for the protection of stream corridors. Loudoun County and County Agencies have professional staff to provide safe drinking water, monitor and control point discharges of pollution, protect citizens from water related health hazards, and monitor and manage stormwater facilities as resources permit. The County and County Agencies also have grant funds to conduct drinking water source protection studies, to monitor surface and groundwater resources, and to begin developing watershed management plans.
- **Citizen Groups** – There are a large number of citizen groups and environmental organizations active in Loudoun County whose goals include environmental stewardship and stream habitat protection. These groups provide a voice for stakeholders and support for use of state and county resources to protect water resources. Citizen groups also have trained volunteers who can collect water samples for physical and chemical analyses, monitor benthic macroinvertebrates, and assess stream habitats. Environmental organizations have trained staff to provide environmental education.

Watershed Level Monitoring¹⁴

Stream monitoring on the watershed level provides data for achieving broader environmental protection objectives. It provides an integrated, inclusive strategy for more effectively protecting and managing surface waters and ground water resources using naturally defined hydrological units (the watershed) as the integrating management unit. The watershed approach to monitoring should emphasize all aspects of water resource quality – physical, chemical, and biological. Stream monitoring offers a means of conducting comprehensive evaluations of ecological status and improvements from restoration activities. Biological assessment integrates the condition of the watershed from tributaries to mainstem through the exposure/response of indigenous aquatic communities.

The steps involved in pollution control are outlined in **Table _**.

¹⁴ EPA. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers*. EPA 841-B-99-002. July 1999

Table __. Steps in Water Resource Protection¹⁵

STEPS	STRATEGIES / PROJECTS
1. Detect water quality and aquatic life impairments	<ul style="list-style-type: none"> • Baseline data collection • 305(b) assessment
2. Assess the relative severity of the impairments	<ul style="list-style-type: none"> • Reference condition documentation • Compare baseline data with WQ standards or reference conditions • 303(d) assessment
3. Identify the specific stress agents causing impairments	<ul style="list-style-type: none"> • TMDL study • Stream walks/assessments • Special studies
4. Identify and limit the specific sources of these stress agents	<ul style="list-style-type: none"> • TMDL Implementation Plan
5. Design appropriate best management practices/treatment to meet the prescribed limits	<ul style="list-style-type: none"> • TMDL Implementation Plan
6. Evaluate effectiveness and compliance	<ul style="list-style-type: none"> • Trend data collection

Combine Probabilistic and Judgment Sampling Design¹⁶

A well-planned stream sampling design will ensure that resulting data are adequately representative of the target stream and defensible for their intended use. The sample design process will also consider the efficient use of time, money, and human resources. A good design will meet the study needs with a minimum expenditure of resources.

There are two main categories of sampling design: probability-based designs and judgment designs. **Probability-based designs** involve random selection of monitoring sites. This allows statistical inferences to be made about the sampled population from the data obtained. These data allow baseline assessments to be made with an efficient use of resources. **Judgment sampling** involves selection of monitoring sites on the basis of expert knowledge or professional judgment. Such stations can be used to track trends in the water quality in a watershed. **Table __** provides a summary of the main features of each type of sampling design. The sample design proposed for Loudoun County combines the use of both these sampling designs.

¹⁵ EPA. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers*. EPA 841-B-99-002. July 1999.

¹⁶ EPA. *Guidance on Choosing a Sampling Design for Environmental Data Collection*. EPA/240/R-02/005. 2002.

TABLE __. Probability-based versus Judgment Sampling Designs.

	Probability-based	Judgment
Advantages	<ul style="list-style-type: none">• Provides ability to calculate uncertainty associated with estimates• Provides reproducible results within uncertainty limits• Provides ability to make statistical inferences• Can handle decision error criteria	<ul style="list-style-type: none">• Can more efficient with knowledge of site and use of historical data• Easier to implement• Preferred for educational purposes and citizen participation
Disadvantages	<ul style="list-style-type: none">• Random locations may be difficult to access• An optimal design depends on an accurate conceptual model	<ul style="list-style-type: none">• Depends upon expert knowledge• Cannot reliably evaluate precision of estimates• Depends on personal judgment to interpret data relative to study objectives• Cannot make statistically valid statements• Constrained by historical site locations

STREAM MONITORING GOALS

On March 6, 2003 state, regional, and local stakeholders participated in the “Comprehensive County Stream Monitoring Plan Design Development Conference” sponsored by Loudoun Watershed Watch at Rust Sanctuary, Leesburg, VA. The purpose of the conference was to identify the stream monitoring goals needed for a comprehensive stream monitoring program for Loudoun County. Participants agreed that healthy streams have a diversity of aquatic life, stable stream banks and substrates, vibrant native vegetation, and healthy floodplain and buffer areas. Stream monitoring should be directed at helping to achieve the goals needed to realize this vision. The stream monitoring goals formulated at this conference and upon which this comprehensive monitoring plan is based are listed in **Table __**.

Table __. Stream Monitoring Goals for Loudoun County.

Reasons for Monitoring	Who Will Use This Data	How Will the Data Be Used?
Goal #1: Characterize and Assess Stream Health:		
• To develop baseline data using probability sampling to characterize the health of a stream	Loudoun County & Agencies, Loudoun Watershed Watch*	Development plan reviews, erosion controls, and baseline stream assessment reports
• To determine whether water quality standards are being met	DEQ	305(b) and 303(d) reports on meeting water quality requirement
• To provide data to develop watershed management plans	Loudoun County & Agencies	Watershed management plans
• To establish stream preservation and restoration priorities	Loudoun County & Agencies, Loudoun Watershed Watch	Stream protection and restoration action plans
Goal #2: Provide Trend Assessments and Forecasts:		
• To document water quality trends over time	DEQ, Loudoun County & Agencies, Loudoun Watershed Watch	Status reports on the health of streams, watershed management plans
Goal #3: Evaluate TMDL Implementation and Watershed Management Plans:		
• To determine whether TMDL implementation is working	EPA, DCR, DEQ	TMDL status reports
• To determine if watershed management plans are effective	Loudoun County & Agencies, Loudoun Watershed Watch	Watershed management plan status reports and assessments
Goal #4: Provide Environmental Stewardship and Education:		
• To educate the community regarding pollution prevention and environmental stewardship	Loudoun County & Agencies, Loudoun Watershed Watch*	Educational materials
• To demonstrate citizen concern regarding water quality and	Loudoun Watershed Watch*	Educational materials

Reasons for Monitoring	Who Will Use This Data	How Will the Data Be Used?
stream health		
Goal #5: Coordinate State, County, and Citizen Resources:		
• Divide monitoring needs rationally between state, county, and citizen groups	NA	NA

* Loudoun Watershed Watch is used to indicate member groups including Loudoun Wildlife Conservancy, North Fork Goose Creek Committee, and Piedmont Environmental Council.

How Monitoring Data Will Be Used by DEQ

Guidance developed by DEQ¹⁷ provides that stream monitoring data from local government and citizen groups that are “approved” will be used by DEQ in their 305(b) stream quality assessment report to EPA. To be “approved,” DEQ requests that all citizen water quality data be sent to DEQ’s Citizen Monitoring Coordinator (CMC). The CMC is responsible for evaluating and approving SOPs, QA/QC plans, training manuals, and current monitoring procedures for citizen monitoring groups. The guidelines for DEQ’s use of approved data are as follows:

- Biological monitoring sites characterized as either “excellent” or “good” will be designated as “Areas of low probability for adverse conditions.” Biological sites periodically characterized as “fair” or “poor” will be designated as “Areas of medium probability for adverse conditions” and listed as fully supporting but threatened. Biological sites that are consistently poor will be characterized as “Areas of high probability for adverse conditions” and listed as fully supporting but threatened with DEQ follow-up monitoring to be scheduled as soon as possible.
- The summaries of local government and citizen data will be placed under a separate Citizen Monitoring section of the 305(b) report.
- Stream segment lengths represented by a local government or citizen monitoring site will be determined by the CMC in conjunction with the local groups using mileage delineation section of DEQ’s 305(b) and 303(d) assessment guidance manual.
- Local government and citizen monitoring data from stations that complement or are comparable to DEQ stations will be used as background data.
- The CMC will provide all “approved” local government and citizen data in the appendices of the 305(b) report.
- Regional DEQ planning and monitoring staff will be given a list of all stations classified as “Area of medium probability for adverse conditions” and “Area of high probability for adverse conditions.” The regional monitoring staff will review the list and consider including appropriate sites in their regional monitoring plan for future monitoring activities.

¹⁷ VA DEQ. “Water Quality Assessment Guidance Manual for Y2002.”

How Monitoring Data Will Be Used by Loudoun County

Loudoun County government has adopted land-use planning, development, and quality of life policies that protect major rivers, stream corridors, floodplains and wetlands, lakes, reservoirs, and impoundments¹⁸. The county recognizes that these natural resources are fragile and irreplaceable, and, therefore, need protection and preservation. The County's watersheds are the key natural resource element in the Green Infrastructure, and will be used as its primary organizing unit.

Loudoun County government will use stream monitoring data to help implement a variety of county programs including the following:

- Loudoun County General Services, Stormwater Management Program (LCGS) -- LCGS will use stream monitoring data to assess the impacts of stormwater discharges into Loudoun streams and evaluate the effectiveness of stormwater rehabilitation programs.
- Loudoun County Building and Development (LCB&D) – LCB&D will use stream monitoring data to identify threatened stream corridors that need to be protected with best management practices for stormwater and other non-point pollution from developments.
- Loudoun County Health Department, Division of Environmental Health (LCHD) – LCHD will use stream monitoring data to identify failing septic disposal systems, and to evaluate the effectiveness of septic system restoration programs.
- Loudoun County Sanitation Authority (LCSA) – LCSA uses stream monitoring data for drinking water source protection studies that include limited assessments of riparian buffers and stream erosion.
- Loudoun County Soil and Water Conservation District (LCSWCD) – LCSWCD uses stream monitoring data to help evaluate the effectiveness of cost-sharing programs for landowners who install agricultural best management practices. (*Pat – please edit this.*)

The County will be developing comprehensive watershed management plans to help identify best management practices that are needed for individual watersheds. Water quality data will be a critical component of these watershed plans, and new water quality data will be needed for many stream segments impacted by stormwater and agricultural practices and segments that will be subject to future development.

How Monitoring Data Will Be Used by Citizen Groups

Citizen monitoring groups in Loudoun County are dedicated to maintaining clean and healthy streams in Loudoun County, and educating citizens about the importance of our streams and stream corridors to people and wildlife. These groups use stream monitoring data to:

- Identify trends in water quality and stream health in Loudoun watersheds over time;
- Develop baseline water quality and stream health data to supplement state and local data;
- Identify potential water quality and stream health problems;

¹⁸ Loudoun Comprehensive Plan, Chapter Five, The Green Infrastructure: Environmental, Natural, and Heritage Resources, 2002.

- Assess the impacts of land use activities (urban, industrial, and agricultural) on water quality and stream health;
- Provide educational materials to the local community and stream users about pollution prevention and environmental stewardship; and
- Show public officials that citizens care about the health of streams and the wise management of water resources.

Many of the activities of these groups are supported by grant funds from DEQ and other organizations such as the Audubon Naturalist Society, Izaak Walton League, Canaan Valley Institute, Chesapeake Bay Restoration Fund, and National Fish and Wildlife Foundation.

STREAM MONITORING DESIGN

A comprehensive, countywide monitoring program is needed to establish statistically valid data on stream health.¹⁹ In May 2003 Loudoun Watershed Watch sponsored the “Loudoun County Stream Monitoring Strategy Workshop.” At this two-day workshop, state, regional, and local stakeholders outlined a structure for an updated stream monitoring program. Sampling designs were agreed upon to achieve the different monitoring goals. A summary of the stream monitoring designs developed at this workshop, and now recommended by LWW, is shown in **Table __**.

Table __. Summary of Monitoring Designs To Be Applied in Loudoun County.

Monitoring Goal	Monitoring Design	Implementing Group/Authority
#1	Probabilistic Monitoring	Loudoun County & Agencies, Citizen Groups
#1 & #4	Watershed Survey	Loudoun County & Agencies, Citizen Groups
#2	Trend Monitoring	DEQ, Citizen Groups
#3	TMDL Validation	DEQ, Loudoun County & Agencies, Citizen

I. Probabilistic Monitoring Design

Summary

The probabilistic monitoring design is used to characterize the impact of nonpoint pollutants and other stress factors on the health of benthic communities and stream habitats in wadeable streams. A probabilistic monitoring design provides comprehensive information about large geographic areas, while keeping costs reasonable.

- Loudoun County should follow the sample design recommended by DEQ and collect samples once at each probabilistic site. Sampling should occur during mid-March to mid-May to compensate for seasonal variations and different phases of benthic organism life cycles.
- Sites should be proportionally distributed among major subwatersheds on the basis of size in acres. Site selection should also be stratified by stream order to assure approximately equal representation among 1st, 2nd, 3rd and 4th order streams.

Purpose

An assessment of nonpoint pollution sources and other stress factors provides data to establish the nature and extent of the impact on the stream’s ecological health and aquatic life. Probabilistic sampling design provides randomly selected, unbiased data that can be used to statistically characterize stream health within the basin being sampled. The probabilistic design

¹⁹ Loudoun Watershed Watch. “State of Loudoun Streams: 2002.” 2002

should be applied on the same subwatershed basis as will be used for subwatershed management plans.

Siting

It is recommended that Loudoun County sample 50 sites per year for five years for a total of 250 samples. The random selection of probabilistic sampling sites should be accomplished by computer, using _____ protocols. Procedures recommended for determining the number of sample sites to be selected in each watershed are as follows:

- Divide major watersheds into 28 subwatersheds of 440 acres or more (see **Attachment ____**). (Although this is an arbitrary size, it appears to result in a reasonable number of subwatersheds.)
- Divide the total acres within the 28 watersheds by 250 to calculate the proportionate number of sampling stations per watershed;
- “Adjust” the proportionate number of sampling stations to provide a minimum of seven (7) stations in each subwatershed by taking sampling stations away from large watersheds and adding them to smaller watersheds;
- Divide the streams within the subwatershed into 100 yard sampling segments and apply an unique identifier to each segment as well as its stream order;
- Group the sampling segments in each of the 28 subwatershed by stream order, and randomly selected a proportional number of sampling sites from each stream order group so the sampling sites selected reflect an equal representation of stream orders; and
 - *(Do we want to stratify the sample in this manner? Do we want equal representation from each strata? Are we taking enough samples in each subwatershed to make this practical?)*
- Select an equal number of alternative sites for substitute sites, as needed.

Parameters

Probabilistic stations should be sampled for the parameters listed in **Table ____**. It is recommended that benthic macroinvertebrates and stream habitat are the primary indicators to be used to characterize stream health. See **ATTACHMENT ____** for a discussion of stream health indicators.

Table ____. Minimum Sampling Parameters for Probabilistic Sampling Stations in Free Flowing Streams.

Parameter	Sampling Protocol	Analytical Protocol
Rainfall	Weather station	
Water Temperature	Thermometer	
pH	LaMotte Kit	Field Kit Instructions
DO	LaMotte Kit	Field Kit Instructions
Turbidity	Visual assessment	
Stream Flow	Visual assessment	

Parameter	Sampling Protocol	Analytical Protocol
Nitrates	LaMotte Kit	Field Kit Instructions
Phosphates	LaMotte Kit	Field Kit Instructions
Benthic Macroinvertebrates	20-1 sq.ft. jabs with D-net in representative habitat along 100 yd stream segment – preserve sample for lab ID*	Contract lab/DEQ lab ID**
Stream Habitat	RBP – visual assessment	
Pollution Sources Inventory	ANS – visual assessment	
Stream Cross Section	ANS	

* DEQ's sample collection protocol using LWC D-nets will be followed.

** Funds need to be secured for services at contract labs.

Frequency

Probabilistic sites should be sampled once during the springtime (March - May) of the year to control for seasonal variations. Sampling each station once will provide the maximum number of samples from the available resources.

- **5-Year Sampling Plan and Schedule** – It is recommended that specific subwatersheds be sampled over a two or three-year interval. A priority should be given to subwatersheds in which TMDL Implementation Plans are being developed in order to develop better baseline data that can be used to evaluate TMDL compliance. Monitoring sites should also be clustered geographically in the county to the extent possible. This approach will allow volunteers to see results of their monitoring efforts in the shorter-term. The proposed sampling schedule is provided in **Table __**.
- Once sampling is completed in all subwatersheds, resampling specific subwatersheds should be scheduled on an as needed basis.
- *(Alternative Plan -- Sampling 50 sites each year can be designed to evenly distributed the sites over all watersheds in Loudoun. The advantage of this approach is that the accumulated data for each watershed will reflect conditions over the five-year period and be less impacted by yearly fluctuations. The disadvantage is that data users must wait five years for data on any particular watershed, and this may delay development of watershed management and stream restoration plans).*

Table __. Five-Year Sampling Schedule for 250 Probabilistic Samples for 28 Subwatersheds in Loudoun County.

Subwatershed	TMDL Status	Size/Stream Order	# Samples 2004 - 2008
Spring 2004 – Spring 2005			
• Catoctin Cr – Mainstem	TMDL Implementation - 2004	10,527 / 5th	4 / 4 / 0 / 0 / 0
• Catoctin Cr – Milltown Creek	None	5,528 / 1st	3 / 4 / 0 / 0 / 0
• NF Catoctin Creek	TMDL Implementation - 2004	14,911 / 4th	6 / 5 / 0 / 0 / 0

Subwatershed	TMDL Status	Size/Stream Order	# Samples 2004 - 2008
• SF Catoctin Creek	TMDL Implementation - 2004	20,171 / 3rd	4 / 5 / 5 / 0 / 0
• Catoctin Cr – Brens Creek	None	7,089 / 2nd	4 / 3 / 0 / 0 / 0
• Limestone Branch	TMDL Implementation - 2005	10,342 / 3rd	4 / 4 / 0 / 0 / 0
• Piney Run	TMDL Implementation - 2005	9,543 / 2nd	4 / 4 / 0 / 0 / 0
• Dutchman Creek	None	8,257 / 2nd	3 / 4 / 0 / 0 / 0
• Clarks Run	None	5,441 / 2nd	4 / 3 / 0 / 0 / 0
• Goose Creek – Little River	TMDL Implementation - 2005	15,745 / 2 nd	4 / 3 / 4 / 0 / 0
• NF Goose Cr - Mainstem	TMDL Implementation - 2005	20,304 / 3 rd	3 / 3 / 4 / 4 / 0
Spring 2006 – Spring 2008			
Broad Run - Mainstem	None		0 / 0 / 2 / 2 / 4
Upper Broad Run	None		0 / 0 / 0 / 4 / 6
Broad Run – Beaverdam Run	None		0 / 0 / 2 / 2 / 3
Broad Run – Horsepen Run	None		0 / 0 / 0 / 3 / 4
Bull Run – Cub Run	None		0 / 0 / 0 / 3 / 5
Upper Bull Run	None		0 / 0 / 0 / 3 / 4
Lower Goose Creek – Mainstem	TMDL Implementation - 2005		2 / 3 / 4 / 5 / 0
Goose Creek – Sycolin Creek	TMDL Implementation - 2005		2 / 2 / 5 / 0 / 0
Goose Creek – Tuscarora Creek	None		0 / 0 / 4 / 3 / 0
Middle Goose Cr. - Mainstem	None		0 / 0 / 3 / 3 / 4
NF Goose Cr. – Crooked Run	None		0 / 0 / 4 / 3 / 0
NF Goose Cr – Upper Beaverdam – Mainstem	None		0 / 0 / 3 / 3 / 4
NF Goose Cr - Upper Beaverdam - Dog Br	None		0 / 0 / 2 / 2 / 3
NF Goose Cr – NF Beaverdam	TMDL Implementation - 2005		3 / 3 / 4 / 0 / 0
Upper Goose Cr – Mainstem	None		0 / 0 / 4 / 4 / 5
Upper Goose Cr – Panther Skin	None		0 / 0 / 0 / 3 / 4
Upper Goose Cr - Panther Skin -Jeffries Br	None		0 / 0 / 0 / 3 / 4

Data Analysis

Statistical analysis of the physical, chemical, and bacteriological data is relatively straightforward because most common statistical analysis procedures assume that the data were collected randomly. Basic statistical summaries can be used to summarize the data including estimates of mean, proportions, and variability.

Habitat and biological assessments are discussed in ATTACHMENT ___. Biological conditions can be analyzed using a multimetrics approach and either a reference stream or streams or the new Virginia Biological Index (VBI) being developed by DEQ in 2003.

Quality Assurance/Quality Control (QA/QC)

Quality assurance measures need to be compatible with the capabilities of county authorities and citizen watershed organizations. QA/QC parameters should include the following:

- Written, detailed protocol comparable with DEQ guidelines;
- Training/Certification for monitors;
- Data quality objectives as provided in **Table __**;
- Equipment inspection and maintenance;
- 10% level of repeat field collection and assessment by separate monitoring team; and
- Mixing of field monitoring team members between different monitoring sites.

The recommended QA/QC objectives for the probabilistic sampling program for Loudoun County are summarized in **Table __**.

Table __. Quality Objectives for Probabilistic Sampling.

Monitoring Parameter	Quality Objectives
Benthic Macroinvertebrate Sample	80% precision in collecting representative sample 90% accuracy in ID 90% accurate of count 90% completeness on data sheet
Habitat Assessment	80% precision in scoring 90% completeness on data sheet
Pollution Source Assessment	80% precision in scoring 90% completeness on data sheet
Stream Cross Section	80% precision in measurements 90% completeness on data sheet
Other parameters and meta data	90% completeness on data sheet

State/County/Citizen Role

Countywide probabilistic sampling has not been attempted previously in Loudoun County. Expanding monitoring to include this new design will require additional resources from each of the parties committed to a collaborative monitoring program. It is envisioned that each party will contribute the following to implement the comprehensive strategy:

- **DEQ** – DEQ should provide:
 - Technical guidance on probabilistic design and monitoring site selection;
 - Certification of citizen and County trainers;
 - Laboratory identification of benthic macroinvertebrate samples;
 - Sharing DEQ stream monitoring data; and
 - Transferring state, local government, and citizen data to EPA's STORET.
- **County** – Loudoun County and County Agencies should provide:
 - A County Stream Monitoring Liaison Officer;
 - Maps of sampling sites;
 - Letters to property owners on whose property monitoring will need to occur;
 - A county website on which monitoring data will be provided;
 - Funding for benthic macroinvertebrate sample ID at a contract lab;

- Funding for field test kits for physical and chemical parameters; and
 - Hand-held GPS units to locate and record sampling sites.
- **Citizen** – LWW should provide:
 - A Citizen Stream Monitoring Coordinator supported by grant funds;
 - Volunteer stream monitors;
 - Training for field stream monitor teams;
 - Benthic macroinvertebrate sample collection equipment;
 - Field collection of samples and assessment of habitat parameters; and
 - Field QA assessments.

Training Required

Loudoun County has a core cadre of trained stream monitors currently volunteering with citizen watershed organizations. The County Stream Monitoring Liaison Officer, the Citizen Program Coordinator and selected county and citizen team leaders will need additional training in proper water and benthic macroinvertebrate sample collection and analyses, in habitat survey techniques, in assessment of pollution impacts, and in diagramming stream cross-sections using the designated protocols. Experienced trainers from federal, state or national organizations should provide this training. This cadre of trained team leaders can then train other county and citizen monitors.

II. Watershed Survey Design

Summary

A watershed survey is the collection of new and existing information on conditions and processes at the watershed level.²⁰ This information can be used to identify the type of additional monitoring that may be needed and problem areas for corrective action, and to bolster watershed awareness and education at all levels, including the individual landowner, community groups, and county authorities.

A watershed survey is an important step in developing watershed management plans. It has two parts:

- **Information Research Survey** – Existing information from reports, interviews, and public meetings regarding stream and watershed conditions and characteristics is compiled; and
- **Field Surveys** – Field data and visual observations on various watershed conditions and characteristics are collected.

²⁰ Pennsylvania Citizen's Volunteer Monitoring Program and River Network. "Designing Your Monitoring Program." 2001. p. 5-6.

A Watershed Survey is also an important component of a TMDL Implementation Plan. It can identify specific stream segments where controls can be applied to reduce NPS pollution loads, or erosion and sediment problems that impact aquatic life.

Purpose

A Watershed Survey is a starting point in the development of watershed management plans and TMDL Implementation Plans because it provides basic information on the watershed that can be used to determine which areas or issues need to receive attention. The information can be used to establish monitoring priorities that most efficiently use monitoring resources, and to identify best management practices that will address the most critical needs. The results can also be used to develop community education and awareness programs and materials.

Siting Criteria and Priorities

The goal is to conduct an Information Research Survey on the entire length of a stream, and a Field Survey on as much of a stream as possible. Considerations for determining which stream segments should receive the highest priority for Field Surveys includes:

- Stream segments that contain problem areas that might be a high priority for some corrective action;
- Stream segments that contain special resource areas such as parks and public access; and
- Stream segments that contain threats to human and aquatic life uses of the water.

Priority should also be given to streams on which TMDL Implementation Plans are being developed. Further, priority should be given to headwater streams that are in subwatersheds that show good stream health and should be protected against degradation.

Survey Parameters

Data collected from an Information Research Survey can be used to narrow the geographic and topical scope of a watershed monitoring plan. It can help direct monitoring to specific reaches or areas of the watershed where current uses and human impacts threaten the health of the stream and need to be assessed with a Field Surveys. The activities associated with each type of survey are summarized in **Table __**.

Table __. Summary of Activities Conducted During a Watershed Survey.

Survey Activities	Parameters and Methods Applied
Research Watershed Information – Literature search for reports, plans and other known documents pertaining to the watershed to identify uses, values, threats, and conditions.	Possible sources of information: <ul style="list-style-type: none"> • EPA Surf Your Watershed • DEQ Regional Offices • Soil and Water Conservation District • Loudoun County LCSA • Loudoun County Mapping

Research Citizen Concerns – Survey citizen uses, values, and perceived threats to the watershed.	Hold a public meeting for watershed residents to identify local uses, values, and threats
Field Survey – Survey the stream, riparian, and watershed characteristics and conditions including: <ul style="list-style-type: none"> • Habitat assessment • Macroinvertebrate assessment • NPS and erosion assessment • Stream channel cross section 	Preferred protocols include: <ul style="list-style-type: none"> • Visual assessment based upon EPA RBP • Watershed Field Inventory (Adopt-A-Stream) • EPA BioRecon • COG RSAT* • CWP Riparian Improvement Tracking (RIP)**

*Galli, J. 1996. Final Technical Memorandum: Rapid Stream Assessment Technique (RSAT) Field Methods. Washington Metropolitan Council of Governments (COG).

**Center for Watershed Protection (CWP). 1998. "Rapid Watershed Planning Handbook." Ellicott City: Center for Watershed Protection.

Schedule of Field Surveys

It is recommended that Field Surveys be conducted on a one-time basis for the purpose of helping to develop monitoring plans for a particular watershed and TMDL Implementation Plans. Follow-up Special Surveys can be conducted if there are seasonal or event-oriented problems that need further investigation (e.g., storm event pollution runoff).

Field Survey should be scheduled for the summer months when college interns may be available to assist, and for the fall when stream access is easier. A recommended schedule for Field Surveys is provided in **Table __**.

Table __. Proposed Five-Year Schedule for Watershed Surveys.

Watershed	Purpose	Date for Field Survey
Limestone Branch	TMDL Implementation	Summer 2004
Piney Run	TMDL Implementation	Fall 2004
Sycolin Run	TMDL Implementation	Summer 2005
SF Catoctin Creek	TMDL Implementation	Fall 2005
NF Catoctin Creek	TMDL Implementation	Summer 2006
Little River	TMDL Implementation	Fall 2006
NF Goose Creek	TMDL Implementation	Summer & Fall 2007
Beaverdam Creek	TMDL Implementation	Summer & Fall 2008

Data Analysis

The results of the watershed survey are a set of quantitative measures and qualitative observations. These data and observations can be recorded in a spreadsheet or database,

analyzed using EPA RBP methods, and summarized on tables and graphs on maps in order to reveal and present problems areas for action. The maps can include:

- Areas where data to make management decisions are lacking;
- Areas of different land uses;
- Problems and conflicts that need to be resolved by management decisions;
- Special areas in need of protection; and
- Special projects to address problems found in the assessment.

Quality Assurance/Quality Control (QA/QC)

Recommended Quality Assurance/Quality Control measures that should be applied to Field Surveys include the following:

- Written, detailed protocol comparable with DEQ, CWP, and COG guidelines;
- Training/Certification for surveyors;
- Data quality objectives as provided in **Table __**;
- Equipment inspection and maintenance;
- Mixing of field monitoring team members between different monitoring sites;
- 10% level of field observation by project coordinator; and
- 10% level of lab analysis of preserved field benthic macroinvertebrate samples.

Table __. Quality Objectives for Watershed Surveys.

Monitoring Parameter	Quality Objectives
Benthic Macroinvertebrate Sample	80% accuracy in ID 90% accurate of count 90% completeness on data sheet
Habitat Assessment	90% completeness on data sheet
Pollution Source Assessment	90% completeness on data sheet
Stream Cross Section	90% completeness on data sheet
Other parameters and meta data	90% completeness on data sheet

State/County/Citizen Role

Countywide Watershed Surveys have not been attempted previously in Loudoun County, although they have been applied in specific areas by COG and CWP with success. Expanding monitoring to include this design will require additional resources from each of the parties committed to a collaborative monitoring program. It is envisioned that each party will contribute the following to implement the comprehensive strategy:

- **State –**
 - DEQ to provide technical support in establishing Information Research Survey and Field Survey protocols, and in selecting stream segments for Field Surveys; and
 - DCR to provide technical support in incorporating Watershed Survey data into TMDL Implementation Plan.

- **County** – Loudoun County and County Agencies should provide:
 - Information Research Survey support for each watershed to be surveyed;
 - Funding for a citizen Watershed Survey Project Coordinator (20 hr/wk for 8 months)
 - Funding for two summer interns (40 hrs/wk for 2 months) to conduct Field Surveys
 - Funding for two fall interns (20 hrs/wk for 4 months) to conduct Field Surveys
 - Mapping and data analysis support
 - GPS units for Field Surveys
- **Citizen** – LWW should provide:
 - Watershed Survey Project Coordinator to lead project;
 - Citizen volunteer survey members to work with interns;
 - Trainers for training on conducting Field Surveys;
 - Field Survey equipment and materials;
 - Data recording, analysis, and report preparation; and
 - QA/QC implementation

Training Requirements – LWW member organizations have a core cadre of trained volunteers who can conduct Field Surveys. The Watershed Survey Project Coordinator should be trained by the organization that developed the assessment protocol being used. The Project Coordinator or another experienced surveyor can then train survey team members. Following the training, surveyors can be observed in the field gathering data to assure that training is effective. Follow up field audits can also be used to assess the adequacy of training.

III. Trend Monitoring Design

Summary

Representative water quality data from any permanent monitoring station can be used to evaluate trends in water quality at the station. Documentation of short-term, mid-term, and long-term trends can be used to assess water quality and best management practices implemented to restore water quality. Trend sampling stations must be carefully selected based upon professional judgment to provide data to answer specific questions about water quality and stream health.

Trend data from one monitoring site can be combined with other trend data to produce trend analyses for larger drainage areas. The sampling methods and laboratory analytical methods must be standardized to combine data from various stations or to compare trends in different streams. Further, the timing of sample collection must be kept relatively constant from month to month and year to year in order not to introduce additional variables.

Purpose

Trend stations are established to provide data for detecting and evaluating tendencies in long-term water quality changes. They provide a balance between limited time and resources and sampling as many parameters as possible using relatively simple methods. The data can also be used to identify problem areas for further monitoring, and for educational and awareness purposes at the community and watershed levels.

Siting

To date, the stream monitoring data collected in Loudoun County by DEQ, LWC, LSWCD, and NFGC have been trend data from monitoring stations selected on the basis of professional judgment. These monitoring stations are listed by watershed in **Table __** and shown on **Map __**. These materials are found in **Appendix __**. To the extent possible these stations should be maintained, although some modifications are needed where existing stations of different groups are clustered.

Additional trend monitoring sites should be established to:

- Provide monitoring data in subwatersheds not currently sampled, and
- Provide additional trend data in subwatersheds subject to TMDL management in order to help assess the effectiveness of TMDL implementation.

Selecting additional trend stations to meet these needs should be based on considerations used by DEQ to site their trend stations²¹.

- Sites should be located where benthic macroinvertebrate samples can be taken.
- Sites should be located near the mouth of the drainage area to evaluate the loadings being discharged to the subsequent downstream watershed; either upstream or downstream of the confluence.
- On mainstem streams containing water from multiple upstream tributaries, sites should be located near the discharge into the Potomac River.
- Sites should represent different stream orders (sizes).
- New sites should be located to the extent possible near flow gauging stations or near locations where flow can be accurately interpolated from gauging station in the same or in adjacent drainages. The volume of water passing the sampling site (flow or discharge rate) is an important water quality parameter and is required to calculate “pollution loadings.”

Based on these considerations, a recommended list of trend stations is provided in **Table __** and shown in **Map __**. Gauging stations are also shown on this map. Adjustments made to the existing monitoring station locations are indicated in the table.

²¹ DEQ. 1999. “Virginia’s Water Quality Monitoring Strategy.”

Table __. Proposed Trend Stations for Loudoun County Including Monitoring Organization. (To be added)

Monitoring Site Location	Organization	Monitoring Parameters			
		Chemical/ Physical	Bacterial	Habitat	Benthic

Parameters and Protocols

Trend stations should be monitored for all parameters that are subject to water quality standards and are included in the Chesapeake Bay Tributary Strategy requirements. Additional parameters can be monitored, especially by DEQ, as resources permit. The basic parameters are listed in **Table __**.

Sampling Protocols – The sampling protocols and analytical methods used may need to vary between government and citizen organizations.

- DEQ will use methods and protocols required under state water quality standards.
- Data collected by County authorities and County Agencies for physical, chemical, and bacteriological parameters should be uniform with DEQ methods and protocols, if funds are available for analyses at contract labs. If not, the county should use protocols consistent with those used by citizen groups.
- Physical, chemical, and bacteriological data collected by citizen groups will likely not be used to enforce state and Federal laws, and protocols can be selected that are less costly and do not require a contract lab for analysis. However, if these data are needed to assess compliance with Federal and state laws and/or county ordinances, then DEQ sampling and analytical protocols and contract labs will need to be used.
- County monitoring for benthic macroinvertebrates should follow the DEQ/LWC protocol guidelines. Citizen monitoring groups will follow either the DEQ/LWC or the 2002 SOS protocol at their choosing.
- A **Loudoun Stream Monitoring Protocol Committee** of state, county, and volunteer group representatives will be formed by LWW to help establish uniform parameters

between the county and citizen groups that are consistent with DEQ guidelines, to the extent possible.

Table __. Minimum Sampling Parameters for Trend Sampling Stations in Free Flowing Streams.

Parameter	Sampling Protocol	Analytical Protocol	Frequency
Water Temperature	Thermometer		Bimonthly
pH	LaMotte Kit		Bimonthly
DO	LaMotte Kit		Bimonthly
Turbidity			Bimonthly
Water Flow			Bimonthly
Nitrates	LaMotte Kit		Bimonthly
Phosphates	LaMotte Kit		Bimonthly
Benthic Macroinvertebrates	LWC/SOS		Spring & Fall
Stream Habitat	LWC		Yearly
<i>E. coli</i> Bacteria			Bimonthly

Frequency

Trend assessments require as many samples collected under as many different conditions as resources will allow. An important consideration is providing enough samples to produce a statistically reliable trend analysis particularly with respect to understanding variability. In order to produce the needed information, trend stations should be sampled for a minimum of five years.

It is recommended that Loudoun adopt DEQ's frequency of sampling trend stations which is:

- bimonthly (6 times per year) for chemical and bacteriological parameters,
- yearly for stream habitat, and
- twice yearly for biological parameters.

If resources do not permit this level of sampling for at least five consecutive years, trend stations should be sampled for least two years out of every six-year period following the model established by DEQ in 2002.

Collecting benthic macroinvertebrate samples at an increased number of trend stations twice yearly will only be feasible if Loudoun County provides funding for the identification of benthic samples at a professional laboratory or funds for a biology technician who can do the ID work in-house. If funds are not available, benthic macroinvertebrate monitoring will likely be limited to those sites currently being monitored by citizen groups.

Supplementing DEQ Sampling – Most trend stations monitored by DEQ will be monitored two years out of every six years. It is recommended that Loudoun County and citizen groups continue to monitor some of these sites during the off-four year period if any of the sites meets the following criteria:

- The site is in a watershed with a TMDL Implementation Plan, or
- The site is in a watershed that is considered “threatened” by DEQ due to identified NPS, nutrient, sediment, or aquatic life problems.

Data Analysis

Basic statistical summaries should be used to summarize the data and to reveal patterns over time at a site as follows:

- Seasonal and/or annual averages to show values typical of the data set;
- Seasonal and/or annual medians to show values typical of the data set;
- Maximums and minimums to show extreme conditions; and
- Range to show variability.

Results will be compared with reference conditions during the sampling year, and over time from year to year. Reference conditions include water quality standards, informal guidelines established by federal or state authorities, and actual results from county or regional reference sites. Reference sites are discussed in **APPENDIX __**.

Quality Assurance/Quality Control (QA/QC)

The quality assurance and quality control measures that should be applied include the following:

- Written, detailed protocols comparable with DEQ guidelines;
- Training/Certification for stream monitors/sample collectors;
- Data quality objectives as provided in **Table __**;
- Equipment inspection and maintenance;
- Mixing of field monitoring team members between different monitoring sites;
- 10% level of field observation by project coordinator; and
- 10% level of lab analysis of preserved field benthic macroinvertebrate samples.

Table __. Quality Objectives for Trend Sampling.

Monitoring Parameter	Quality Objectives
Benthic Macroinvertebrate Sample	80% precision in collecting representative sample 90% accuracy in ID 90% accurate of count 90% completeness on data sheet
Habitat Assessment	80% precision in scoring 90% completeness on data sheet
Pollution Source Assessment	80% precision in scoring 90% completeness on data sheet
Other parameters and meta data	90% completeness on data sheet

State/County/Citizen Role

DEQ has been monitoring in Loudoun County for over 20 years, and Loudoun Soil and Water Conservation Service and citizen groups have been monitoring since 1997. The citizen monitoring has been supported with grant funds from DEQ and other sources. Expanding monitoring to include additional trend stations and parameters will require additional resources from each of the parties committed to a comprehensive monitoring program in Loudoun County. It is envisioned that each party will contribute the following to enhance trend monitoring:

- **State** – DEQ should provide:
 - Continued monitoring at designated ambient water quality stations;
 - Technical assistance in selecting additional trend stations for county and re-siting stations for citizen groups as necessary;
 - Training and QA oversight of county operations; and
 - Technical guidance on monitoring protocols to the Loudoun Stream Monitoring Protocol Committee.
- **County** – Loudoun County and County Agencies should provide:
 - Funding for a County Stream Monitoring Program Coordination position to provide training, data entry, data analysis, report preparation, protocol updates, and QA oversight of county and citizen monitoring activities;
 - Funding for the analysis of bacteriological samples at a professional laboratory;
 - Chemical field test kits, sample collection materials, and suspended solids testing equipment to loan to citizen groups as necessary;
 - Funding for two part-time intern positions as stream monitors to collect samples at new sites and unsampled DEQ sites; and
 - Funding of a biology technician to do benthic macroinvertebrate sample ID, or funding for ID work at a professional laboratory.
- **Citizen** – LWW organizations should provide:
 - Continued monitoring at existing trend sites with expanded parameters as necessary;
 - Loudoun Stream Monitoring Protocol Committee to provide uniform protocols for monitoring;
 - Training and QA oversight of program; and
 - Equipment for benthic macroinvertebrate sampling.

Training Required – Loudoun Soil and Water Conservation District and LWW member organizations have a core cadre of trained individuals who can monitor streams and collect chemical samples. The Loudoun Stream Monitoring Coordinator should be trained by DEQ in the assessment protocols being used. The Coordinator or another experienced monitor can then train stream monitor team members. Following the training, monitors can be observed in the field gathering data to assure that training is effective. Follow up field audits can also be used to assess the adequacy of training.

IV. TMDL Validation Monitoring Design

Background

At an April 2003 meeting with DCR regarding TMDL implementation in the Catoctin Creek watershed, Loudoun County was advised that it will need to take lead responsibilities for any TMDL implementation. Although DEQ has responsibility at the state level to assess TMDL implementation, and they have advised they will do this in the future when remedial controls have been installed, their assessment will be very limited. Under law, DEQ focuses on the short segments of the watershed for which they have monitoring data and which have been classified as impaired. They have no monitoring data for large portions of the watershed that are contaminated and in which remedial controls are needed if water quality standards are to be met throughout the watershed. Therefore, it is important that Loudoun County provide supplemental monitoring if an effective validation of the TMDL Implementation Plan is to be made. TMDLs involve legal requirements and validation data collection and analytical protocols will need to meet DEQ requirements.

Summary

Supplemental TMDL validation monitoring is needed in watersheds where water quality impairments have been documented by DEQ and pollution controls are being developed and implemented by Loudoun County in cooperation with DCR. A validation assessment is designed to document the effectiveness of the best management practices (BMPs) that have been installed to improve the water quality. The primary assessment conducted by DEQ will be limited to small stream segments currently designated as impaired. Supplemental assessments conducted by Loudoun County and citizen groups will target stream segments not monitored by DEQ. If data results suggest that the implemented management controls are not effective, recommendations on redesigning the management controls are considered by DEQ. Data collected through the Probabilistic and Trend monitoring designs will be used to validate TMDL implementation.

Purpose

Segments of stream in Loudoun County designated as impaired by DEQ are based upon an analysis of existing stream monitoring trend station data. DEQ did not conduct comprehensive studies of the water quality throughout the watersheds to determine which sections are impaired and which meet water quality standards. DEQ's data also do not include stream survey, habitat, or aquatic life data that characterize conditions in the watersheds. Consequently, the segments designated as impaired often reflect the "tip of an iceberg" rather than true water quality conditions in the watershed. This is evidenced by the findings of the Goose Creek TMDL study wherein DEQ determined that nonpoint pollution existed throughout the watershed and that all tributaries needed pollution controls if water quality standards are to be met. Therefore, DEQ's existing data from their trend stations cannot be relied upon to provide an adequately baseline to validate the effectiveness of pollution controls instituted under TMDL Implementation Plans.

Siting

It is recommended that the same monitoring stations established under the probabilistic and trend monitoring designs be used to develop the baseline, trend, and validation data needed to evaluate the effectiveness of TMDL implementation.

- **Baseline Data** – The problem of inadequate data is compounded by the fact that the purpose of a TMDL validation-monitoring site is to document a change in water quality. To accomplish this, baseline water quality data are needed on impaired streams before control measures are installed. This needed baseline data can be collected through the probabilistic sampling design.
- **Trend Data** – Trend stations are needed to measure a change from the baseline and improvements in water quality in impaired streams over the time period of the TMDL implementation. In watersheds such as Goose Creek, this should include trend stations for each of the major subwatersheds and major tributaries. Trend data are to be collected from stations located on the basis of professional judgment.
- **Validation Data** – A second baseline assessment using the same probabilistic sampling design should be undertaken once the trend data suggest that significant progress has been made in meeting water quality standards,.

Parameters

TMDL Implementation will focus primarily on BMP improvements in riparian buffers in agricultural areas in order to decrease runoff and protect stream banks from erosion caused by livestock. These BMP improvements should show changes in benthic macroinvertebrate and stream habitat conditions and in bacteriological levels making these good parameters for validating TMDL implementation. The same parameters used in the probabilistic and trend monitoring designs can be used to validate TMDL controls.

Data Analysis

Data used to validate TMDL Implementation will include both probabilistic data and trend data that will allow a broad range of statistical analyses.

- Statistical analysis of the physical, chemical, and bacteriological data is relatively straightforward because most common statistical analysis procedures assume that the data were collected randomly. Basic statistical summaries can be used to summarize the data including estimates of mean, proportions, and variability.
- Habitat and biological conditions can be analyzed using a multimetrics approach and either a reference stream or streams or the new Virginia Biological Index (VBI) being developed by DEQ in 2003.
- Trend data can be analyzed using basic statistical summaries including:
 - Averages to show values typical of the data set;
 - Correlations to show the degree of differences between data sets; and

- Comparisons with various reference conditions including water quality standards, informal guidelines established by federal or state authorities, and actual results from county or regional reference sites.

State/County/Citizen Role

Expanding monitoring to include a second initiative of probability sampling after TMDL implementation will require additional resources from each of the parties committed to a comprehensive monitoring program in Loudoun County. It is envisioned that each party will contribute the following to validate TMDL implementation:

- **State –**
 - DEQ and DCR to provide technical support in establishing County TMDL validation plans that will complement DEQ plans; and
 - DEQ/DCR to recognize county and citizen assessment data in their validation of TMDL implementation and assessment of water quality conditions.
- **County –**
 - Play the lead role in collecting and analyzing stream monitoring data to provide supplemental TMDL implementation validation data; and
 - Fund the probabilistic and trend monitoring needed to provide the professional level data to help validate TMDL implementation.
- **Citizen –**
 - Provide supporting trend and stream survey monitoring data to the county to help validate TMDL implementation.

RECOMMENDATIONS

Loudoun County's Green Infrastructure Strategy provides a guide for the development of environmental policies. The county recognizes that its water resources are fragile and irreplaceable, and, therefore, need protection and preservation. The County's watersheds are the key natural resource element in the Green Infrastructure, and are being used as its primary organizing unit.

The policies and ordinances adopted to implement the Green Infrastructure Strategy come at a critically important time because, concurrently, the Virginia Department of Environmental Quality (DEQ) published findings that most streams in Loudoun County have impairments and do not meet the Virginia Water Quality Standards. Virginia is required under the Federal Clean Water Act to identify impaired waters and work with local governments and communities to restore the water resources to meet standards.

To help address these problems, the Loudoun County Water Resources Technical Advisory Committee has been tasked with the development of a Water Resources Protection Plan. The plan is to have three components: (1) water quality protection, (2) water quantity protection, and (3) watershed management. Stream monitoring is a part of the watershed management component of the Water Resources Protection Plan.

It is Loudoun Watershed Watch's (LWW) vision²² that Loudoun County government and County Agencies will become the principal authorities that collect water resource data, and prepare and implement watershed management plans with the support of citizen watershed organizations. Stream monitoring can best be achieved through the collaboration of federal, state, regional, and local authorities; and citizen watershed organizations. A countywide monitoring plan that incorporates the contributions of each party will provide comprehensive coverage and effective use of limited state, county, and volunteer resources.

Stream Monitoring Program Structure

In 2002 Loudoun Watershed Watch published The State of Loudoun Streams: 2002 report that provided recommendations regarding needs for watershed management planning and stream monitoring. These recommendations provide an outline for a County administrative structure that can accomplish these important goals.

- Loudoun County should create a **Water Resource Management Administrator** to oversee the development of watershed management plans and the implementation of TMDL plans for Loudoun streams. A system of small subwatersheds should be identified that provide homogeneous management areas. Additional information regarding impervious cover and loss of forest lots will aid management planning. The authority needs to work with the Loudoun Watershed Watch to bring together stakeholders to support this process.

²² Loudoun Watershed Watch. "State of Loudoun Streams: 2002." 2002.

- Loudoun County should support a **countywide stream monitoring program** to assess changes in stream health and progress in restoring water quality to supplement state efforts. The program should utilize low cost methods to assess bacteriologic quality, habitat conditions, and biological conditions.
- Loudoun County should adopt an updated **stream monitoring program and strategy** so the county can play a leadership role in water resource protection. The updated strategy should focus on providing more representative data on watersheds, and on measuring the effectiveness of land stewardship initiatives to restore water quality. This can be best accomplished by randomly selecting additional monitoring sites in each watershed to provide a **probabilistic sampling program**. A better balance between assessments of chemical, bacteriological, habitat, and biological parameters is needed to provide an accurate picture of stream health conditions. Increased monitoring by county and citizen groups should be encouraged to offset reductions in monitoring by the state.

Collaborative Approach to Stream Monitoring

Water quality data will be critically important as Loudoun County begins developing comprehensive watershed management plans. New water quality data will be needed for many stream segments impacted by stormwater and agricultural practices and segments that will be subject to future development.

Collecting the needed stream monitoring data can best be achieved through the collaborative efforts of federal, state, regional, and local authorities; and citizen watershed organizations. A countywide monitoring plan that incorporates the contributions of each party will provide comprehensive coverage and effective use of limited state, county, and volunteer resources.

Federal – The U.S. Environmental Protection Agency (EPA) administers the Federal Clean Water Act and oversees implementation of the Act by the Virginia Department of Environmental Quality (DEQ). EPA sets standards and provides guidelines for water quality monitoring, stream protection, and water quality restoration. Loudoun County receives grant funds and technical guidance from EPA. The U.S. Geological Survey (USGS) records stream flows at ten locations in Loudoun County, and provides real-time flow data. USGS also provides grant funds and technical guidance on water quality, and stream protection and restoration.

State – State agencies have the legal mandate and professional staff to monitor streams and ensure that state water quality standards are met. They have a large amount of historical trend monitoring data at stations throughout the county. They provide grant funds and technical support to local governments and citizen groups as resources permit regarding monitoring, watershed management planning, and pollution control. DEQ uses county and citizen data to help identify threatened waters that need state study.

- **DEQ** – DEQ should provide:
 - Technical guidance on probabilistic design and monitoring site selection;

- Technical support in establishing Information Research Survey and Field Survey protocols, and in selecting stream segments for Field Surveys;
- Technical assistance in selecting additional trend stations for county and re-siting stations for citizen groups as necessary;
- Technical guidance on monitoring protocols to the Loudoun Stream Monitoring Protocol Committee;
- Training of citizen and County trainers and QA oversight of county operations;
- Laboratory identification of benthic macroinvertebrate samples; and
- Transferring state, local government, and citizen data to EPA's STORET.
- **DCR** – DCR should provide:
 - Technical support in incorporating Watershed Survey data into TMDL Implementation Plans.
- **DEQ/DCR** – DEQ and DCR should provide:
 - Technical support in establishing County TMDL validation plans that will complement DEQ plans; and
 - Recognition of county and citizen assessment data in their validation of TMDL implementation and assessment of water quality conditions.

County Government and Agencies – Loudoun County and County Agencies have laws and ordinances that protect stream corridors. They have professional staff to provide safe drinking water, monitor and control point discharges of pollution, protect citizens from water related health hazards, and monitor and manage stormwater facilities, as resources permit. The County and County Agencies also have contract funds to conduct drinking water source protection studies, to monitor surface and groundwater resources, and to begin developing watershed management plans.

Loudoun County and County Agencies should provide:

- Funding for full and part-time County or County Agency positions as follows:
 - a County Stream Monitoring Liaison Officer;
 - two summer interns (40 hrs/wk for 2 months) to conduct Field Surveys;
 - two fall interns (20 hrs/wk for 4 months) to conduct Field Surveys;
 - two part-time intern positions as stream monitors to collect samples at new sites and unsampled DEQ sites; and
 - a biology technician to do benthic macroinvertebrate sample ID, or funding for benthic macroinvertebrate sample ID at a professional laboratory;
- Contract funds for a citizen Watershed Survey Project Coordinator (20 hr/wk for 8 months)
- Leadership in collecting and analyzing stream monitoring data to provide supplemental TMDL implementation validation data;
- Training and QA oversight for county operations;
- Chemical field test kits, sample collection materials, and suspended solids testing equipment to loan to citizen groups as necessary;
- Information Research Survey support for each watershed to be surveyed;
- Mapping and data analysis support for sampling sites;

- Letters to property owners on whose property probabilistic monitoring will need to occur;
- A county website on which monitoring data will be provided; and
- Hand-held GPS units to locate and record sampling sites.

Citizen Groups – Citizen groups and environmental organizations help lead efforts in Loudoun County to promote environmental stewardship and stream habitat protection. These groups provide a voice for stakeholders and support for use of state and county resources to protect water resources. Citizen groups also train volunteers who collect water samples for physical and chemical analyses, monitor benthic macroinvertebrates, and assess stream habitats. Environmental organizations have trained staff to provide environmental education.

LWW organizations should provide:

- A Citizen Stream Monitoring Coordinator supported by grant funds;
- A volunteer Watershed Survey Project Coordinator to lead Watershed Survey project;
- A Loudoun Stream Monitoring Protocol Committee to provide uniform protocols for monitoring;
- Citizen volunteer survey members to work with interns;
- Volunteer stream monitors to collect field data and conduct field assessments;
- Continued monitoring at existing trend sites with expanded parameters as necessary;
- Field Survey equipment and materials including benthic macroinvertebrate sample collection equipment;
- Data recording, analysis, and report preparation;
- Training for field stream monitor teams; and
- Field QA/QC implementation.

ATTACHMENT __ STREAM HEALTH INDICATORS

Indicators are used to measure human impacts that upset the balanced conditions found in a natural stream ecosystem and cause major degradation problems. There are a number of indicators that can be used to assess the health of a stream.

Physical and Chemical Indicators -- Water quality programs have traditionally relied on physical, chemical and bacterial indicators to assess quality, and most data collected by DEQ in Loudoun County is physical, chemical and bacteriological data. Evaluating water quality by using key physical and chemical indicators can reveal degradation from nonpoint pollution sources. The key physical and chemical indicators to be used in Loudoun County for both baseline data and trend data are summarized in **Table __**.

TABLE __. Key Physical and Chemical Indicators of Water Quality to be Used in Loudoun County.

Parameter	Description
Flow	Stream flow is the volume of water that moves over a designated point over a fixed period of time. It is a function of water volume and water velocity. Stream flow can have an impact on water quality and on the living organisms and habitats in the stream.
Water Temperature	Temperature is measured in degrees Fahrenheit (F) or degrees Celsius (C). Temperature affects the oxygen content of the water, and macroinvertebrates will move in the stream to find acceptable temperatures. Temperature will vary with width and depth of a stream.
Turbidity	Turbidity is a measure of water clarity, or how much the material suspended in water decreases the passage of light through the water. Suspended materials include clay, silt, sand, algae, plankton, microbes, and other substances typically in the size range of 0.004 mm to 1.0 mm. Turbidity can affect the color of the water. Turbidity can be useful as an indicator of runoff from construction, agricultural practices, and other sources especially in developing watersheds that have high proportions of impervious surfaces. Higher turbidity reduces the amount of photosynthesis and the production of DO. In slower waters, suspended materials will settle out and smother benthic macroinvertebrates.
pH	pH identifies the acid/base balance of water. pH affects many chemical and biological processes in water. Most aquatic organisms prefer a range of 6.5 to 8.0. pH values outside this range cause stress to most organisms and reduce reproduction. Low pH values can indicate acid rain. The Virginia water quality standard for pH is 6.0 – 9.0.

Dissolved Oxygen (DO)	.A small amount of oxygen, up to about ten molecules of oxygen per million of water, is dissolved in water and breathed by fish and zooplankton. Swiftly moving waters contains more dissolved oxygen than stagnant water, and cold water holds more oxygen than warm water. Bacteria also consume dissolved oxygen when digesting organic matter, such as septic system wastes and cow manure. Too much organic material in streams can cause oxygen-deficiency. The Virginia standard for dissolved oxygen is a minimum of 4 mg/L.
Phosphorus	Phosphorus is a plant nutrient in short supply in most fresh waters. It usually limits the growth of plants. Even modest increases can accelerate plant growth, cause lower dissolved oxygen, and lead to the death of fish and macroinvertebrates. There is no Virginia standard, but there is a screening value of 0.2 mg/l. The maximum level set by EPA is 1.0 mg/L. Sources include sewage discharges; runoff from lawns, golf courses, and croplands; manure; failing septic systems; and drained wetlands.
Nitrate-Nitrogen	Nitrogen is also an essential plant nutrient. Like phosphorus, excessive levels of nitrogen encourage the growth of plants. If phosphorus rises to high levels, then nitrogen becomes the limiting factor. There is no Virginia standard, and EPA has not set a maximum level. Sources include runoff and non-point pollution.

Bacteriological Indicators – Wastes from warm-blooded animals including human sewage, livestock, and wildlife release disease-causing organisms into streams. Fecal coliform bacteria are used to indicate the potential presence of human pathogens and the likelihood of a public health threat. Higher concentrations cause greater public health concerns. DEQ considers recreational waters to be impaired or unsuitable for use when more than 10% of the water samples collected over a 2-5 year period are greater than 1000 fecal coliform colonies per 100 ml of sample (FC MFN/100ml).

Habitat Indicators – Stream habitat includes rocks and sediment substrate on stream bottoms, plants in and around streams, root wades in stream banks, and leaf litter and other organic materials used for food in streams. Aquatic insects are found in greatest numbers in streams that provide good substrate, food, and dissolved oxygen.

Citizen monitoring protocols recognize that stream habitat is degraded by unstable conditions, and that monitoring can provide measures of habitat health. Factors that cause stress to stream habitats include stream bank erosion, sediments covering the stream bottom, and loss of trees in the riparian buffer. Stream habitats are also degraded by changes in water flow that upset a stream's energy equilibrium and cause bank erosion. A natural and balanced stream habitat is needed to preserve a diverse and balanced biological community.

Habitat conditions are an important indicator of stream health because aquatic insects and fish have specific habitat requirements. The habitat assessment used by DEQ and citizen groups is based upon EPA's Rapid Habitat Assessment Form (1997). This assessment measures the following in-stream characteristics:

- Pools, riffles, and runs including availability of attachment sites for macroinvertebrates;
- Composition of the stream bottom substrate including the amount of embeddedness and sediment deposition;
- Channel alteration and the amount of flow in the channel; and
- Condition of stream banks including the amount of bank vegetation protection and riparian vegetative zone protection.

Biological Indicators – Biosurvey techniques are used to monitor pollutants that affect aquatic organisms, and to evaluate the relative seriousness of the impacts. Aquatic organisms (also called benthic macroinvertebrates) include the aquatic insects, crayfish and other crustaceans, clams and mussels, snails, aquatic worms, and other similar organisms. Insects comprise the largest diversity of these animals and include mayflies, stoneflies, caddisflies, and midges. They cycle nutrients, and are major food sources for fish and other aquatic animals. **Figure 2.1** (*to be added*) illustrates the benthic macroinvertebrates commonly found in streams.

- **Importance of Benthic Macroinvertebrates** – These organisms are excellent indicators for assessing streams because they cannot escape changes in water quality. Each insect has requirements the stream must provide for the insect to flourish. By determining the number and type of insects that live in a stream, the quality of the water and the health of the stream environment can be assessed. If pollution impacts a creek, the number and type of macroinvertebrates will change. For example, stonefly nymphs are sensitive to most pollutants. If habitat and chemical parameters, such as high dissolved oxygen and low sedimentation levels are good, a stream will support this type of insect and can be considered healthy. If a stream has many pollution tolerant insects, such as midges and black fly larva, or few insects of any species, then the biological assessment indicates that the stream ecosystem is “sick.”
- **Reference Stream** – Virginia’s water quality standard includes a general requirement that all state waters are to be free of pollutants that are harmful to animal, plant, or aquatic life. This standard allows the state to consider stream habitat and aquatic insect populations as indicators of stream quality. To apply the standard, DEQ compares measurements from the stream being monitored with measurements from another stream of known good quality called a “reference stream.” The reference stream represents the “natural,” unimpaired conditions found in a stream of similar size and in the same geographic “ecoregion.”

The reference streams used by DEQ are the lower Rapidan River for muddy bottom streams and Catoctin Creek at Taylorstown for rocky bottom streams. Most streams in Loudoun County are rocky bottom streams. DEQ calculates the percent similarity between the monitored and reference streams for both the habitat and aquatic organisms.

- **Biological Condition Metrics** – Aquatic insect are collected to measure the “biological condition” of the stream segment being monitored. Four primary measurements or metrics recommended by EPA²³ are described in **Table __**.

TABLE __ . Primary Biological Condition Metrics.

Number of taxa	<i>Number of families of organisms (taxa) present. A high number of taxa indicates a high diversity in the aquatic insect community and good stream health</i>
EPT Index	<i>Number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) compared to the total number of individuals in the sample. These three families of insects indicate good water quality because they are most susceptible to pollution.</i>
Percent Dominant Taxon (PDT)	<i>Proportion of individuals in the most dominant family (taxon) compared to the total number of organisms in the sample. The PDT should be less than 20% in headwater streams to indicate good conditions.</i>
Modified Hilsenoff Biotic Index (MHBI)	<i>Each taxon is assigned a pollution sensitivity or tolerance value. The MHBI is calculated by multiplying the number of individuals in each taxon with the sensitive value for the taxon. The MHBI should be less than 2 in headwater streams to indicate good conditions.</i>

- **Multimetric Approach** – Virginia has found that EPA’s basic metrics do not always adequately distinguish health streams from unhealthy streams. Studies have shown²⁴ that benthic macroinvertebrate communities are in dynamic equilibrium with the physical, chemical and biological components of their environment. Metrics are human attempts at simple numerical characterizations that try to reflect this equilibrium and the very complex interactions that underlie it. Pollution and other environmental stresses change the equilibrium, and metrics must change predictably in relation to the severity of these stresses.

The multimetrics approach attempts to characterize species composition, diversity, and functional organization in unstressed, natural habitats in a region and in a variety of stressed habitats in the same region. The structural elements (such as the kind and number of organisms) and the functional processes (such as organism habits and roles) within the community are measured to characterize the biological community. A multivariate analysis is used to “establish percentiles of the population distribution of the reference sites for the metrics to discriminate between impaired and minimally impaired conditions.”²⁵

²³ EPA. “Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003. 1997.

²⁴ Voshell, J. R., Hiner, S. 2003. *Freshwater Biomonitoring Using Benthic Macroinvertebrates*. National Conservation Training Center, May 19-23, 2003.

²⁵ EPA. 1999. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers*. EPA 841-B-99-002.

ATTACHMENT _____
ANALYTICAL PROTOCOLS
(To be added)

ATTACHMENT ***QUALITY MANAGEMENT***

The purpose of a Quality Management Program is to document policies, goals, objectives, and general procedures by which Loudoun County intends to produce and validate acceptable water quality data. Implementing a plan that encompasses the various field collection, analyses, and data recording activities will ensure that decisions made with the data will be based upon sound science based principles and environmental data of known and acceptable quality.

It is recognized that data collected by Loudoun County authorities and citizen groups will not be used by DEQ to classify Loudoun watersheds and stream segments. Rather, these data will be used to identify "Threatened Streams." This designation is used to DEQ when data from citizen monitoring or other governmental units for stream segments indicate the need for additional monitoring by DEQ. These stream segments are considered "Special Study Sites" by DEQ and require project and quality assurance plans.

Therefore, the quality assurance measures to be applied for Loudoun County authorities and for citizen monitoring conforms with DEQ's "Water Quality Assessment Guidance Manual for Y2002," Part VI, Section 6.3.1, Citizen Monitoring. This guidance provides for all citizen water quality data to be sent to DEQ's Citizen Monitoring Coordinator (CMC). The CMC is responsible for evaluating and approving SOPs, QA/QC plans, training manuals, and current monitoring procedures for citizen monitoring groups. Under this guidance, data collected by local government and citizen groups will be used in DEQ's 305(b) stream quality assessment report to EPA as follows

- Biological monitoring sites characterized as either "excellent" or "good" will be designated as "Areas of low probability for adverse conditions." Biological sites periodically characterized as "fair" or "poor" will be designated as "Areas of medium probability for adverse conditions" and listed as fully supporting but threatened. Biological sites that are consistently poor will be characterized as "Areas of high probability for adverse conditions" and listed as fully supporting but threatened with DEQ follow up monitoring to be scheduled as soon as possible.
- The summaries of local government and citizen data will be placed under a separate Citizen Monitoring section of the 305(b) report.
- Stream segment lengths represented by a local government or citizen monitoring site will be determined by the CMC in conjunction with the local groups using mileage delineation section of DEQ's 305(b) and 303(d) assessment guidance manual.
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ATTACHMENT __
DATA MANAGEMENT AND REPORTING
(To be added)

ATTACHMENT __
WATER QUALITY STANDARDS

Virginia's DEQ has authority to enforce the federal Clean Water Act, and U.S. EPA has responsibility to oversee the state's implementation. The State Water Control Law protects high-quality waters and provides for the restoration of other waters so they support reasonable public uses and aquatic life. Virginia has adopted water quality standards under Section 62.1-44.15(3a) to accomplish the law's purposes. Virginia's free flowing streams have been classified into categories based upon physical and chemical characteristics, suitability for specific fisheries and other special standards as found in Virginia's Water Quality Standards (9VAC 25-260-00 et seq., December 10, 1997).

- Part I and Part II of the standards describe, respectively, surface water standards with general, statewide application and standards with more specific application.
- Part VII describe Special standards and scenic rivers designations.
- Part VIII identify nutrient enriched waters.

Virginia Standards – Water quality standards consist of narrative and numeric criteria. These statements and numbers describe the water quality necessary for designated uses such as swimming and other water-based recreation, public water supply, and the support of aquatic life. DEQ and EPA use these standards to limit the amount of pollutants discharged into surface waters. The first level of classification is based upon the limits of normal variation in dissolved oxygen (DO), pH (acidity) and temperature of the waters. Numerical classification criteria for these characteristics are listed in **Table __**. The second level of surface water classification is based upon stream “aesthetics, productivity, resident fish population and stream structure. Loudoun streams are “class ix” which means they are considered unsuitable for any type of trout fishery based upon summer temperatures, a significant population of war-water game fish, or insufficient flow. Other special standards are used to classify waters that are designated as public water supplies.

Anti-Degradation Policy – Virginia's water quality standards include an anti-degradation policy that provides additional protections:

- All existing in-stream water uses and the level of water quality to protect the existing uses must be maintained and protected. This means that at a minimum, all waters should meet adopted water quality standards.
- Any water that is better than specified water quality standards must be protected. Only in limited circumstances may water quality be lowered.

- There are exceptional waters where no new, additional or increased discharges of sewage, industrial wastes or other pollution are allowed. These waters must be specifically listed in the regulation.

Virginia's Tributary Strategy Program – Virginia's Tributary Strategy Program aims to reduce nutrient and sediment loads to tributaries of the Potomac River and Chesapeake Bay. Current levels of erosion, sediments and nutrients throughout the Bay watershed have led to water quality problems that affect smaller creeks and major rivers. Such problems include low levels of dissolved oxygen, high sediment loads, and declining numbers of aquatic insects and beds of submerged aquatic vegetation. The program is based on scientific data and is voluntary. The program includes establishing goals for nutrient and sediment reductions, identifying cost-effective practices for achieving these reductions, and implementing these practices. Each watershed has distinct characteristics, and each requires an individualized approach.

Designated Use Standards – Loudoun streams are designated for “recreational uses, e.g., swimming and boating; the propagation and growth of a balanced indigenous population of aquatic life, including game fish which might reasonably be expected to inhabit them; wildlife . . .” This designated use determines the water quality criteria applicable to Loudoun streams. There are chemical and bacteriological criteria for temperature, pH, dissolved oxygen, ammonia, chloride, and fecal coliform bacteria. These standards are listed in **Table __**. There are no standards for other parameters such as nitrogen, phosphorous, turbidity, suspended solids, or biological oxygen demand (BOD).

Table __. DEQ Water Quality Standards for Recreational Use in Piedmont Zones.

(Source: 9 VAC 25-260-5 et seq. Water Quality Standards, 1/10/97)

Parameter	State Standard (Acute/Chronic)	Significance
Temperature	Maximum = 32 ⁰ C	Affects rates of chemical processes in cells and the water's dissolved oxygen content
pH	6.0 – 9.0	Level of acidity -- affects cell membrane functions
Dissolved Oxygen (DO)	Minimum = 4 mg/l	Affects biological metabolism
Ammonia	0.86 – 32 mg/l as N acute/ 0.19 – 3.02 chronic ¹	Form of nitrogen that in excess causes eutrophication and loss of dissolved oxygen; a toxin
Chloride	860/ 230 mg/l	Indication of salt content
Fecal Coliform Bacteria	200 colonies/100ml or not more than 10% \geq 400 per 100ml	Common bacteria in animals' digestive tracts. Indicator of human sewage or animal droppings.

¹ Standard varies with temperature and pH

² Instantaneous standard is used with monthly sampling schedule.

ATTACHMENT __
LOUDOUN'S RIVER AND STREAM CORRIDOR RESOURCES
POLICIES
(To be added)

ATTACHMENT __
LOUDOUN'S STREAM RESOURCES

Identifying Stream Resources – Loudoun streams have a name of their own, which partially identifies them. Identifying a specific location along a stream, such as a stream monitoring station, is most commonly done using its geographic coordinates of latitude and longitude. Computer generated Geographic Information Systems (GIS) allows geographic coordinates to be represented by decimal degrees.

DEQ uses an additional identifier to describe a specific point on the reference line formed by the water body that is being adopted by Loudoun County to facilitate data sharing. This consists of a water body identification code followed by the number of “river miles above the mouth of the stream on which the point is located. The coding identifiers consist of the following:

- The principal rivers and the tributaries that feed them are first identified by a numerical code for each major drainage basin. Larger stream systems may be divided into major segments or sub-basins that are identified by letter.
- Tributaries and smaller streams with each major basin or sub-basin are then identified by a three-letter code based on the stream name.
- This is followed by a five-digit numerical value that identifies the specific point on the stream as the number of “river miles” upstream from the stream’s mouth.
- The identification codes for the streams in Loudoun County are listed in **Table __**.

Table __. Subwatersheds in Loudoun County with Areas >440 Acres with DEQ/DCR Identification Nomenclature²⁶.

Major Watershed	Subwatershed	Stream Name	Tributary Name	Area in Acres*
Lower Potomac River – Sub Basin 1A				
Broad Run (A09)	Broad Run-Mainstem (BRB)/Cabin Br No.2			10,535
Broad Run (A09)	Broad Run (BRB)	Upper Broad Run (___)		14,251
Broad Run (A09)	Broad Run (BRB)	Beaverdam Run (___)		8,264
Broad Run (A09)	Broad Run (BRB)	Horsepen Run (HPR)		8,594
Bull Run (A21)	Cub Run (A22) (___)/Elklick Run (___)			9,436
Bull Run (A21)	Upper Bull Run (___)			9,309
Catoctin Creek (A02)	Catoctin Creek-Mainstem (CAX)			10,527
Catoctin Creek (A02)	Catoctin Creek	Brens Creek (___)		7,089
Catoctin Creek (A02)	Catoctin Creek	Milltown Creek (MIH)		5,528
Catoctin Creek (A02)	Catoctin Creek	NF Catoctin Creek (NOC)		14,911
Catoctin Creek (A02)	Catoctin Creek	SF Catoctin Creek (SOC)		20,171
Clarks Run (___)				4,449
Direct to Potomac				6,441
Dutchman Creek (___)	Dutchman Creek-Mainstem (___)			8,257
Goose Creek	Lower Goose Creek-Mainstem (A08)(GOO)			21,082
Goose Creek	Lower Goose Creek (A08)	Little River (LIV)		15,745
Goose Creek	Lower Goose Creek (A08) (GOO)	Sycolin Creek (SYC)		10,960
Goose Creek	Lower Goose Creek (A08) (GOO)	Tuscarora Creek (TUS)		9,226
Goose Creek	Middle Goose Creek-Mainstem (A05)(GOO)			12,557
Goose Creek	NF Goose Creek-Mainstem (A06) (NOG)			20,304
Goose Creek	NF Goose Creek (A06)	Crooked Run (___)		8,104
Goose Creek	NF Goose Creek	Upper Beaverdam Cr-Mainstem (A07) (BEC)		13,607
Goose Creek	NF Goose Creek	Upper Beaverdam Cr (A07) Dog Branch		4,623
Goose Creek	NF Goose Creek	NF Beaverdam Creek (A07)(NOB)		12,045
Goose Creek	Upper Goose Creek-Mainstem (A04)(GOO)			18,312
Goose Creek	Upper Goose Creek (A04)	Lower Panther Skin Cr (___)		7,009
Goose Creek	Upper Goose Creek (A04)	Lower Panther Skin Cr (___)Jeffries Branch		5,883
Limestone Br. (A03)	Limestone Branch (LIM)			10,342
Piney Run (A01)	Piney Run (PIA)			9,543

* Acres are taken from Loudoun County GIS Data as provided by David Ward

Subdividing Watersheds – Watersheds in Loudoun County will be divided into smaller drainage basins in a manner that allows the development of a watershed management plan for each. DEQ considers the minimum size of a watershed to be 3000 acres, although smaller watersheds are listed²⁷. A criterion has been adopted by DEQ in determining the minimum size of a watershed that can be used for the application and evaluation of best management practices to maintain or improve water quality. The criterion is whether land use practices are reasonably uniform. *Uniformity is measured in terms of whether the dominant land uses normally generate similar types of NPS, and normally require similar types of BMP's to control the NPS.* If the

²⁶ Virginia Department of Environmental Quality. "Virginia's Water Quality Monitoring Strategy." December, 1999. Page 140.

²⁷ Virginia Department of Environmental Quality. "Virginia's Water Quality Monitoring Strategy." December, 1999. Page 24.

heterogeneity within a watershed may inhibit the application of uniform management plans, and representative monitoring of water quality would also be needed on a more local scale, smaller drainage basins are designated. This criterion has been adopted by Loudoun County.

Stream Order – The stream order classification system best suited for probabilistic sampling is the Shreve or “link” order.²⁸ This system is also useful for relating environmental variables to stream size. Order number is determined by adding the orders of the joining streams (e.g. the union of a 4th and a 5th order stream results in a stream of the 9th order). The Shreve order, consequently, is identical to the number of the 1st order sources that drain through a specific stream segment. The basins draining through any two-stream segments of Shreve order “n” contain exactly the same number of primary sources (n), of stream junctions or “forks” (n-1) and of stream segments (2n-1) or “links” between successive forks or between forks and primary sources. Streams of a specific Shreve order are therefore more uniform in size and the order number is independent of basin complexity. In addition, the order of the downstream “link” below any fork is a more informative measure of the change in stream size when two tributaries join, and the potential reservoir of aquatic species that are available to colonize upstream habitats.

Stream Size Parameters – Within free flowing streams, width, depth, water velocity and total discharge rate (volume per unit time) are extremely important size parameters. They have crucial effects upon the physical and chemical characteristics of the water, which in turn have ecological implications, and are necessary for calculating estimates of total material flow and the Maximum Total Daily Loadings (TMDLs) necessary for management planning and the permitting of point-source discharges. Ecologically and biologically, these stream size parameters are important because they influence the water temperature, oxygen content, the quantity of suspended material that a stream can carry and the size of substrate particles deposited within the streambed.²⁹

Natural, Unimpaired Conditions – Comparison of the observed structure and function of aquatic communities with those expected under “natural,” unimpaired conditions is the first phase of biological assessment of water quality. The biological communities expected under natural conditions vary with (a) the size and form of the stream; and (2) the geographic “ecoregion.” Loudoun County has several options available.

- **Reference Stream** –The reference streams used by DEQ are the lower Rapidan River for muddy bottom streams and Catoctin Creek at Taylorstown for rocky bottom streams. Most streams in Loudoun County are rocky bottom streams. DEQ calculates the percent similarity between the monitored and reference streams for both the habitat and aquatic organisms. Unfortunately, Catoctin Creek at Taylorstown is a 3rd or 4th order stream, and may not a good reference for 1st and 2nd order streams.

²⁸ Virginia Department of Environmental Quality. “Virginia’s Water Quality Monitoring Strategy.” December, 1999. Page 28.

²⁹ Virginia Department of Environmental Quality. “Virginia’s Water Quality Monitoring Strategy.” December, 1999. Page 27.

- **Reference Conditions** -- EPA³⁰ recommend using “reference conditions” rather than reference streams to measure stream health since there are few sites left that reflect the best conditions. The reference condition is a composite of scores from sites that reflect the best physical, chemical, and biological conditions existing in the ecological region. Loudoun County will develop a reference condition index after sufficient probabilistic data is collected.
- **Fairfax County Reference Sites** -- Loudoun County will also consider using reference site data from Prince William Forest. These data are currently being used by Fairfax County, and may be the best data available to Loudoun County from the local ecoregion.

³⁰ U.S. Environmental Protection Agency (EPA). 1997. Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003.

ATTACHMENT __.
HISTORIC TREND STATIONS IN LOUDOUN COUNTY

MONITORING SITE	CHEMICAL	BACTERIAL	HABITAT	BENTHICS
Broad Run - Mainstem • Rt. 7	DEQ 1973-2001	DEQ 1973-2001	None	None
Broad Run – Mainstem • LCSA Property	LCSA 1990-2000	LCSA 1990-2000	None	None (begin in 2002)
Beaverdam Run – Rt. 641	None	None	LWC 2000-2001	LWC 2000-2001
Catoctin Creek - Mainstem • Rt 663	DEQ 1978-2001 LSWCD 1999-2001 LWC 2001	DEQ 1978-2001 LSWCD 1999-2001	DEQ 1997-2001 LSWCD 1999-2001 LWC 1997-2001	DEQ 1997-2001 LSWCD 1999-2001 LWC 1997-2001
North Fork Catoctin Creek -- • Rt 681	DEQ 1973-2001 LWC 2001	DEQ 1973-2001	LWC 1997-2001	LWC 1997-2001
• Rt 287	DEQ 1973-2001	DEQ 1973-2001		
• Rt 690	DEQ 1973-2001	DEQ 1973-2001		
• Rt 719	LSWCD 1999-200	LSWCD 1999-2001	LSWCD 1999-2001	LSWCD 1999-2001
South Fork Catoctin Creek - • Rt 698	DEQ 1973-2001	DEQ 1973-2001		
• Rt 738	DEQ 1973-2001	DEQ 1973-2001		
• Rt 611	LWC 2001		LWC 1997-2001	LWC 1997-2001
• Rt 711	LSWCD 1999-2001	LSWCD 1999-2001	LSWCD 1999-2001	LSWCD 1999-2001
Beaverdam Creek • Rt. 734	DEQ 1976-2001 LSWCD 1999-2001	DEQ 1976-2001 LSWCD 1999-2001	None	LSWCD 1999-2001
• Rt. 731				
• Rt. 626, Foxcroft Rd	DEQ (new site)	DEQ (new site)	None	
North Fork Beaverdam Creek • Rt. 719, Airmont Rd	DEQ (new site)	DEQ (new site)	None	
Butchers Branch • Rt. 831			LWC 1997-2001	LWC 1997-2001
Goose Creek -- Mainstem – • Rt. 7	DEQ 1973-2001	DEQ 1973-2001	DEQ 1996 - 2001	DEQ 1996-2001
Little River – • Rt. 50	DEQ 1973-2001	DEQ 1973-2001	DEQ 1997-2000	DEQ 1997-2000

MONITORING SITE	CHEMICAL	BACTERIAL	HABITAT	BENTHICS
• Rt. 629	LSWCD 1999-2001	LSWCD 1999-2001	None	LSWCD 1999-2001
• Rt. 632	LSWCD 1999-2001	LSWCD 1999-2001	None	LSWCD 1999-2001
Sycolin Creek – • Rt. 15	DEQ 1973-2001	DEQ 1973-2001	None	None
• Rt. 653	DEQ 1973-2001	DEQ 1973-2001	None	None
• Rt. 621	DEQ 1973-2001	DEQ 1973-2001	None	None
• Rt. 797	DEQ 1973-2001	DEQ 1973-2001	None	None
Tuscarora Creek • Rt. 632	DEQ 1973-2001	DEQ 1973-2001	LWC 1997-2001	LWC 1997-2001
S. Fork Goose Cr. • Rt. 734	DEQ 1973-2001	DEQ 1973-2001	None	None
Panther Skin Creek	None		LWC 2000-2001	LWC 2000-2001
	•			
North Fork Goose Creek • Rt. 733	LSWCD 1999-2001	LSWCD 1999-2001		LSWCD 1999-2001
• RT. 722	NFGC 1996-2001	DEQ 1970-2001		NFGC 2000-2001
• Rt. 794, Rt 611	LSWCD 1999-2001	LSWCD 1999-2001		LSWCD 1999-2001
• Rt. 782	NFGC 1996-2001 LSWCD 1999-2001	LSWCD 1999-2001	LWC 1997-2001	LWC 1997-2001 NFGC 2000-2001 LSWCD 1999-2001
• Rt. 630			LWC 1997-1998	LWC 1997-1998
• Rt. 729	NFGC 1998-2001 LSWCD 1999-2001	LSWCD 1999-2001		NFGC 2000-2001 LSWCD 1999-2001
• Villages at Round Hill	NFGC 1996-2001			NFGC 2000-2001
Crooked Run				
• Rt. 727	NFGC 1996-2001		LWC 1997-2001	LWC 1997-2001 NFGC 2000-2001
• Rt. 725	LSWCD 1999-2001	LSWCD 1999-2001		LSWCD 1999-2001
Limestone Branch • Rt. 15	DEQ 1974-2001	DEQ 1974-2001	None	None
• RT. 661	None	None	LWC 1997-2001	LWC 1997-2001
• Rt. 740	None	None	LWC 2001	LWC 2001

MONITORING SITE	CHEMICAL	BACTERIAL	HABITAT	BENTHICS
Piney Run - Main Stem • Rt. 671	DEQ 1990-2001	DEQ 1990-2001	None	None
• Rt. 683	LSWCD 1999-2001	LSWCD 1999-2001	None	LSWCD 1999-2001
• Rt. 685	LSWCD 1999-2001	LSWCD 1999-2001	None	LSWCD 1999-2001
Piney Run • Sweet Run Tributary	None	None	LWC -- 2001	LWC -- 2001

Virginia Index of Biological Integrity (IBI) – DEQ has developed an IBI (index of biological integrity) from an analysis of historical data collected in Virginia. The IBI provides a reference condition based upon statewide averages. Loudoun will use this index until sufficient probabilistic data is available to do comparison analyses.